THURSDAY, AUGUST 3, 1899.

NORWEGIAN MARINE INVESTIGATIONS.

Bergens Museum. Report on Norwegian Marine Investigations, 1895–97. By Dr. Johan Hjort, O. Nordgaard and H. H. Gran. (Bergen: John Grieg, 1899.)

THIS Report contains two papers, the first, on the "Currents and Pelagic Life in the Northern Ocean," by Drs. Hjort and Gran, and the second, "A Contribution to the Study of Hydrography and Biology on the Coast of Norway," by O. Nordgaard.

In the first paper, the authors give the general results of their observations on the hydrography and pelagic life of the Northern Ocean obtained during recent years. More detailed results of their observations in Norwegian waters, with especial reference to the herring fishery, are reserved for future publication.

It may at once be said that this work, though only an instalment, is a very important contribution to oceanographical knowledge, and well sustains the character of Scandinavian research.

The first chapter deals with the hydrographical condition of the Northern Ocean, and the second chapter contains plankton studies in the same region. Then follow voluminous and detailed tables of the actual observations. These tables are illustrated by a series of seven plates, which show easily and very clearly the peculiarities of the region under description.

The Northern Ocean, as a deep-water basin, lies on the polar side of a curved line passing through Iceland, the Farö Islands, and reaching the Norwegian coast at the point where its trend changes from north to north-east. The shallow water portion includes all the Norwegian littoral waters and the portion of the North Sea between Norway and Scotland lying north of latitude 57° or 58° N. The Wyville Thomson ridge connecting Iceland with the Farös and the Orkney Islands is debatable ground separating the Atlantic from the Arctic areas. The position and the bathymetric characteristics of the different regions are very well shown in Plate I., taken from Mohn's "Northern Ocean."

Along the entire Norwegian seaboard there are three deep regions of well-marked hydrographic characters: (1) The region of periodical changes to a depth of 200 or 250 metres; (2) the Atlantic region to a depth of 500 metres; and (3) the Arctic region. Referring to this classification, the authors say:

"Of these regions it is chiefly the uppermost that is of interest to us, as it is our main purpose to unravel all the conditions which may influence the migration of fishes; and it may well be presumed that the great changes produced by currents, by summer warmth and winter cold, and the variations from year to year of the different factors, may be of the greatest importance to the periodical fisheries."

In pursuing the investigations of these conditions, five sections of the sea off the coast between Stavanger and Lofoten were made in 1895 by Hjort, and the same ground was gone over by Nordgaard in the winter of 1896. The results of these investigations are shown graphically in Plates VI. and VII. The figures in these plates take the form of sections running out from the Norwegian coast to a depth not exceeding 400 metres, and showing the distribution of depth, temperature and salinity. Of these, the most interesting are those made in the same locality in summer and in winter. The difference of season affects principally the water at and near the surface, and is dependent on the rainfall in Norway. If the west coast of Norway were a perpendicular cliff, and the whole of the rain which falls on it ran eastwards, the fluctuation of conditions with which this paper deals would be either non-existent or insignificant. The physical observations of the papers are mainly directed to chronicling the variations in the salinity of the coast waters, and especially in the quantity of water of low salinity, which has a tendency to cover the surface and monopolise the summer heat received from the sun, of which it contributes next to none to the layers immediately below it. This view, that the freshening of the coastal waters, with all its consequences, is due to the mixture of Atlantic water with fresh water from the continent, and not to the addition of water from the Arctic ocean, is developed in considerable detail in the paper. In so far the paper is of a polemical and, indeed, of a more or less national character, because the opposing view is especially identified with Sweden, and the one supported by the authors with Norway. It is, however, a form of polemic from which nothing but profit is likely to result to science. With regard to the evidence afforded by plankton studies, which have been held to favour the Arctic theory, the authors say in their *résumé*:—

"As all inflowing bodies of oceanic water are of an Atlantic kind, the Arctic organisms, which may be met with at certain times, must in any case pass through Atlantic water if they really are derived from the Arctic currents, but their subsequent appearance in the colder and fresher waters on the coast is no proof of the coastal water's Arctic origin."

The concluding paper by Nordgaard, dealing mainly with the food of the cod, is very interesting, but not of a kind to be easily abstracted. In presenting the results of his investigations, he makes some important remarks. He admits that the fluctuations of the herring fishery are largely, though not exclusively, due to changes in the physical conditions of the sea in the spawning regions.

Referring to the cod, he says:—

"We are thus led to the conclusion that a principal factor in the produce of the Lofoten fisheries is the number of the fish that migrate inwards, and as the migration from the ocean, according to the observations hitherto made goes on in such a great depth that the annual variations in the physical conditions are very insignificant, we are obliged to look for another explanation of the change, in the numbers of the immigrations. I am apt to think that much can be derived from changes in the numbers of the fish staying on the outer banks. In the same way in which we speak, for instance, of a bad grouse season, by which we mean that the number of grouse is small, we may certainly also speak of a bad cod season."

It will be seen that this, as well as the preceding papers, are of a very detailed character, and they well repay careful study.

J. Y. B.

PROJECTIVE GEOMETRY.

Premiers Principes de Géométrie Moderne. Par E. Duporcq. Pp. viii + 160. (Paris: Gauthier-Villars, 1899.)

IT is a curious fact that while projective geometry is becoming better appreciated in England it seems to be going out of favour in France. M. Duporcq, in his introduction, pathetically deplores the predominant place assigned to analysis in the syllabuses of the official examinations; and in France, as with ourselves, most teachers are compelled to neglect a subject that does not pay. It will be sad indeed if, in the fatherland of Monge, Poncelet and Chasles, pure geometry is to be deposed from her former high estate, and made a kind of Cinderella, called in to do odd jobs for Her Serene Highness the Princess *Analyse*, or to amuse the children with tricks of the triangle.

M. Duporcq's book itself helps us to realise the danger that is threatened. One cannot help feeling that his attitude is apologetic, and that his exposition is a half-hearted one. At the very outset we are confronted with homogeneous coordinates; homography is based on an algebraic relation; points at infinity lie in a plane "by definition"; imaginary elements have no real existence, and the introduction of them, due to analysis, is a mere *façon de parler*, vaguely justified by the "Principle of Continuity." With all respect to Poncelet, it may be doubted whether his "principle of continuity," apart from algebraical considerations, has any real working value; on the other hand, von Staudt elaborated, forty years ago, a theory of imaginary elements which, so far as curves and surfaces of the second order are concerned, gives a consistent geometrical theory (quite independent of analysis) in which the principle of continuity has a real meaning, and is at the same time practically self-evident, as one would expect it to be. Von Staudt's name does not appear to be mentioned in M. Duporcq's book, and the reader might not unreasonably infer that the author was ignorant of v. Staudt's existence.

It would, of course, be absurd to advocate the exclusive use of pure, as opposed to analytical, geometry, even in problems of a strictly geometrical character. The ideal geometrician should be equally expert in both methods, and apply one or the other or both combined according as circumstances may require. But it may fairly be urged that a treatise on the *first principles* of projective geometry should avoid the introduction of coordinates except by way of illustration, and for the purpose of showing the points of contact between the two methods. It is right to teach an apprentice the use of a saw as well as that of a plane; but you will not attain this end by giving him a tool that is neither a saw nor a plane, but contains something of both.

Thus to give an explicit example, M. Duporcq frequently infers homography from a one-to-one relation established, not from an equation, but from the inspection of a figure. Thus (p. 49):

"Si donc m et m' désignent les deux points où une droite quelconque Δ coupe une conique circonscrite au quadrangle $a\ b\ c\ d$, on voit qu'à tout point m de Δ ne correspond ainsi qu'un point m'. Comme, d'ailleurs, ces points sont évidemment réciproques, ils déterminent donc une involution sur Δ," &c.

These statements are doubtless correct, but are they sufficiently justified? How is the beginner to distinguish the argument from the following:

"Two points S, H are taken on a tangent to an ellipse, and any ellipse with foci S, H cuts the given ellipse in the points M, M': then to each point M corresponds one point M' and *vice versâ*, hence we have a system in involution, and MM' goes through a fixed point"?

It is not a sufficient answer to say that M, M' are only a pair of four associated points, because this is not geometrically evident. Again, we have cases of Cremona correspondence with the fixed points imaginary: how is the untrained student to distinguish them from homographic correspondences?

We are far from wishing to suggest that M. Duporcq's work is devoid of interest and value. Considering its size it is remarkable for the range and variety of its contents; it comprises a very attractive and, indeed, brilliant sketch of homography, poles and polars, involution, quadratic transformation (including inversion), together with an outline of Lie's line-sphere correspondence. For a reader prepared by previous study, it affords an excellent and suggestive *résumé;* it is rather when it is examined as a methodical text-book for students that it seems to us to fall short of perfection. To the student we would still say: Read Reye, work his exercises, and then, if you like the subject, gird up your loins and tackle von Staudt. For it is a truth past gainsaying that v. Staudt's "Geometrie der Lage" and the immortal "Beiträge" contain, as no other books do, the essentials of projective geometry. G. B. M.

A SYSTEM OF PHYSICS.

Kanon der Physik. By Felix Auerbach. Pp. xii + 522. (Leipzig: Viet and Co., 1899.)

SCIENTIFIC books may be divided into two groups, those which are written because the author has something to teach, and those which are written because he has something to learn. It is no reproach to a writer if his book is classed with the second group, for there may be as much originality in learning as in teaching, and his autodidactic efforts will often prove a source of instruction to others. It is not possible to say whether Prof. Auerbach has been consciously writing his "Kanon" of physics to clear up his own ideas on scientific principles, but the book he has produced gives the impression that this has been one of his principal motives; and I would even go a step further and say that, if life were long enough, every physicist ought, when he gets to the age of fifty, to spend three years in putting his ideas into shape and write a similar treatise. It would serve as a kind of "Abiturienten Examen" to his state of crystallisation.

It is easier to talk about this book in vague and general terms than to give an account of what it is and what it contains. I am afraid of becoming definite in my own words, for fear of giving a wrong impression, and must content myself with the translation of a few sentences taken out of the preface.

"A comprehensive book is still wanting—and not only in Germany—in which the conceptions, principles,

theorems and formulæ, dimensional relations and numbers belonging to physics are represented and put together in a systematic manner, and in a way which would do justice to two different intentions: to give on the one hand to the reader a general view of the whole, without disturbing him by methodical, historical and other details, and on the other hand to give without circumlocution, to any one who may consult the book, a definite answer to his questions. The great difficulty in principle of such a 'Kanon' of physics lies clearly in the fact that it is in exact science often, perhaps generally, impossible to give a short answer to a short question. If a scientific man is asked, What is mass? What is elasticity? What is entropy? he takes a long breath and begins with a long introduction—and not without reason; for the difficulty of a short and detached answer lies in the nature of the thing. But we must not consider the difficulty to be insurmountable. We must fix our mind on what is essential and characteristic, and give expression to it in our answer; as for the rest, so far as is necessary, it may be added afterwards by supplementary remarks."

The volume which the author has produced to satisfy his requirements is worth reading because it is stimulating. Irritating would perhaps be the better word for the principal sensation felt in perusing it, because we constantly come across statements which do not seem to coincide with our own views, or with explanations which do not satisfy; yet in spite of trying hard, it is difficult sometimes to point out what it is that does not satisfy, and even if one succeeds one feels that the thought one has been obliged to give to the matter has cleared and perhaps modified one's own views. The book begins with a number of chapters on general principles, space, time, motion, force and mass and the properties of matter. The subject is treated in a concise, short and instructive manner, but the author does not always succeed in giving us, as promised in the above passage, a short answer to a short question. His definition of dispersion, *e.g.*, takes up eight lines and wants reading eight times before it can be understood. After a short chapter in which the principal equations of the potential theory are put together and explained, the author enters into the two chief divisions of the book, "energy" and "entropy." He takes a rather wide and unusual view of the latter word, including under it all transformations of energy. Without entering into the difficult question of classification, we may commend these two chapters, which most physicists will read with profit. But surely a better definition of electric current might be given than the one on p. 250:—

"When one observes, that the potential has different values at different points of a conductor, one expresses this fact also by saying: a certain quantity of electricity moves in the conductor, or an electric current flows in it."

The difference of potential at different points is by no means characteristic of an electric current, as for instance in air, where we are constantly dealing with such differences. Dr. Auerbach, to make his explanation correct, must therefore lay stress on a sharp distinction between conductors and non-conductors; but how would he define a conductor except by arguing in a circle, and saying that a body is a conductor when a fall of potential causes an electric current.

Among the points of the book which are irritating without being stimulating, we may mention the very annoying method of numbering concurrently and independently his paragraphs, according as they contain matters of principle or laws and propositions. Thus § 52, printed in fat type, follows § 158 printed in somewhat leaner characters, and whenever a reference has to be looked up, one has to investigate the type carefully, and if it is, *e.g.*, 91 fat, turn to p. 385; while if it is 91 lean, find the required passage on p. 118. We hope that in future editions a different system will be adopted.

Lecturers will find one use, perhaps not a very high one, for this book; it will save them thought and labour, by helping them to arrange their course in a systematic and orderly fashion. ARTHUR SCHUSTER.

OUR BOOK SHELF.

Insects: their Structure and Life. A Primer of Entomology. By George H. Carpenter, B.Sc. (Lond.). Pp. xi + 404. (London: J. M. Dent and Co., 1899.)

MR. CARPENTER, Assistant Naturalist in the Science and Art Museum in Dublin, is favourably known to entomologists by numerous valuable papers on *Lepidoptera*, *Odonata*, cave-insects, economic entomology, &c.; and we are very pleased to welcome a useful introductory manual of entomology from his pen. It is compiled from a variety of sources, special use having been made, in the chapters on the form and life-history of insects, of the well-known work on the cockroach by Profs. Miall and Denny. These chapters will be found very useful, especially as the names attached to the various parts of insects are clearly and carefully explained. Classification and the principal orders and families of insects are then dealt with as fully as the space at the author's disposal would allow; and chapters on insects and their surroundings and on the pedigree of insects close the body of the book, which concludes with a short bibliography and a good index. Perhaps Chapter v., on insects and their surroundings, will be found most interesting to the general reader; for it treats of such subjects as cave-insects, fresh-water insects, marine insects, geographical distribution, mimicry, &c. Mr. Carpenter usually expresses himself very cautiously, but when he says that the number of described species of insects amounts to a quarter of a million, and that there are probably two millions of species still undescribed, we are inclined to think that both his estimates are very much below the mark. The number of described species of insects cannot be less than 300,000 at present, and many entomologists think that the late Prof. Riley's estimate of the number of existing species of insects as ten millions is by no means to be regarded as extravagant. Mr. Carpenter's remarks on the various subjects connected with evolution are very well expressed and reasoned out. W. F. K.

Year-book of the United States Department of Agriculture, 1898. Pp. 768. (Washington: Government Printing Office, 1899.)

THE volume before us, like so many of its predecessors which have been noticed in these columns, is full of contributions of interest and value to students of science, agriculturists and others. Although appealing primarily to residents in the States, many useful hints and suggestions may be gleaned from the year-book by its readers in this country. The report of the Secretary of the Department shows that the varied operations carried on have been prosecuted with vigour. The Department has at present four scientific explorers abroad getting seeds and plants—one in Russia, one in the countries

in the neighbourhood of the Mediterranean, one in the China Seas, and one in South America. It is stated in connection with the forestry division that 100,000 acres are under forestry experimentation. The State Agricultural Experiment Stations report an active year, about 400 reports and bulletins having been issued during the year to over half a million addresses. As is fitting at the present time, the volume contains special articles on the resources of Puerto Rico and the Hawaiian Islands.

Organoterapia. By Dr. E. Rebuschini. Pp. viii + 442. (Milan: Ulrico Hoepli, 1899.)

IN the introduction Dr. Rebuschini briefly deals with the history and general nature of organotherapy. The main substance of the book is devoted to a detailed account of the glandular secretions and other substances derivable from the several organs of the animal body, and the applications of these fluids to the treatment of disease. As the author points out, the most successful branch of organotherapy up to the present time has been that of the thyroids, and this alone occupies nearly half of the book.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Undercurrents.

IN NATURE for July 13, p. 261, is given an abstract of a paper lately read by Admiral Makaroff, of the Imperial Russian Navy, before the Royal Society of Edinburgh, on the subject of double currents, *i.e.* of currents in reverse directions in different strata of water in certain straits. Admiral Makaroff gives his opinion on the causes of these reverse currents, and as they are diametrically opposed to those that I hold, I think that it may not be uninteresting to give my reasons for differing from him.

Admiral Makaroff considers that difference of density of the water is the primary and, indeed I gather he thinks, the only cause of these opposing currents; but he brings no evidence beyond theoretical considerations in support of his belief.

Let us consider his instance of the Bosporus.

In 1872, as Admiral Makaroff very kindly mentions, I made a series of observations on the undercurrents in this Strait and in the Dardanelles,[1] and showed that when the surface water, of a very low specific gravity, was flowing from the Black Sea to the Mediterranean, the water in the lower strata of the Straits, of a high specific gravity, was running strong in the opposite direction.

But the surface current does not always flow in this direction. It is sometimes almost still, and on occasions the movement is towards the Black Sea. The lower strata respond, and are either also still, or move in the opposite direction.

It is evident that as the Mediterranean water is always of a high specific gravity, and the Black Sea surface water always of a low specific gravity, if the difference between them is the primary cause of the opposing currents the latter would always flow in the same direction, and that as they do not in fact behave in this manner, there must be some other force at work.

My observations soon led me to conclude that this force is the wind.

The prevailing wind in the summer and autumn, in which I made my observations, is from the N.E. When it blew from this direction, the surface current ran towards the Mediterranean. When it was calm the water was in the Dardanelles, ordinarily, still, and in the Bosporus often so. When the wind came from the westward, the currents were reversed.

I do not know how the deduction from these facts can be got over. I am quite ready to admit that the difference in specific gravity will cause a slow circulation in the direction in which the two currents ordinarily run, but in the face of their undoubted reversal under the circumstances which I have related, it appears to me that there can only be one conclusion.

It was on the ground that the direction of the wind is the prevailing factor that I believed that we should find a similar condition of affairs in the Strait of Bab-el-Mandeb, and as I stated in a communication to NATURE, vol. lviii. p. 544, these conditions were, by observations most ably carried out by Commander Gedge, R.N., in H.M.S. *Stork* in 1898, proved to exist.

There are here none of the differences o. specific gravity demanded by Admiral Makaroff's hypothesis, and I consider that the existence of the reverse undercurrent in Bab-el-Mandeb, when the north-east monsoon is forcing the water on the surface into the Red Sea, absolutely proves the correctness of the theory that wind is the primary cause of this interesting circulation. Admiral Makaroff in his paper merely mentions the Strait of Bab-el-Mandeb as a place where the double-currents occur, but says nothing about them; and I am not aware that any observations but those made by H.M.S. *Stork* have been carried out in this Strait.

Admiral Makaroff is a close and indefatigable observer, and oceanography owes him much, but I cannot help thinking that in this instance his enthusiasm for densities has led him away. However, I shall be glad to hear reasons to the contrary, as I only desire the truth.

W. J. L. WHARTON.

Florys, Wimbledon Park, July 25.

[1] Report on the Currents of the Bosporous and Dardanelles. (Hydrographic Office. Potter, London.)

The Duties of Provincial Professors.

SINCE the appearance of the article "The Duties of Provincial Professors" in NATURE, I have daily been wishing to write to thank you for it, but hitherto have been hindered partly by want of a convenient opportunity, and partly by the feeling that all the points brought forward are so absolutely accurate, and the article is so complete, that it leaves nothing further to be said. The warning it contains as to the danger of making true culture subservient to competition is most timely. I have an experience of many years as an officer in a provincial university college, and know, to my cost, how rank is the growth of the spirit of competition with rival colleges, and how widespreading are its roots. And this is at the sacrifice of the best intellects and ability of the colleges. It results usually in the resignation of the most original and brilliant characters who may have sufficient private means to secure a bare independence; while the others remain quite at the mercy of their governing body, who may at any moment—even without any assigned motive—give them notice to resign. This and the very inadequate salaries attached result in constant changes in the staff. Further, the fever of competition induces the different university colleges to take up technical and pedagogical training, adding department after department at a rate greatly in advance of their means, so that no side can be worked to its full development owing to an insufficient staff and an overburdened exchequer.

A question which has frequently arisen in my mind of late is, Are we to allow without protest a different standard of morals to our governing bodies from that accorded to individuals?

In *bulk* their income is derived from public sources; why should councils of university colleges, whose existence depends upon such sources of income, be allowed the power to close their meetings to reporters? Are they to be allowed freedom of method without danger of exposure? Must we quietly allow them to fix the salaries of their officers at their own pleasure at an average which is much below the market value of the services rendered—in some cases even so low as 50 per cent. below the average rate? Is this honest? No: *it is thieving the best energies of some of our most able minds!*

Those of their officers who lack private means know that they dare not speak the thoughts of their hearts. They hardly dare protest, or courteously ask—even in the most considerate manner, for colleges have their known difficulties—for their legitimate due, for they know very well that, until they have another post to step into, they are helpless.

These things ought not to exist. They are a slow poison sapping the life of true education, rendering systems which are almost ideal in theory of no account in practice.

July 25.

VERITAS.

PHOTOGRAPHIC RESEARCHES ON PHOSPHORESCENT SPECTRA:

ON VICTORIUM, A NEW ELEMENT ASSOCIATED WITH YTTRIUM.[1]

It has long been known that certain substances enclosed in a vacuous glass bulb phosphoresce brightly when submitted to molecular bombardment from the negative pole of an induction coil. The ruby, emerald, diamond, alumina, yttria, samaria and a large class of earthy oxides and sulphides emit light under these circumstances. Examined in a spectroscope the light from some of these bodies gives an almost continuous spectrum, while that from others, such as alumina, yttria and samaria, gives spectra of more or less sharp bands and lines. Since 1879 I have been working on these phosphorescent spectra, chiefly in connection with the earths of the yttria group, and by chemical fractionation I have succeeded in separating from this group bodies whose phosphorescent spectra consist chiefly of single groups of lines, other groups being absent. For the last six years the research has been extended beyond the visible spectrum, and photographs of the ultra-violet portion of the spectra are now being taken with a spectrograph with a complete quartz train. Some of the results of this investigation were exhibited at the soirée of the Royal Society on May 3. A preliminary mention of the discovery of a new element was made in my address to the British Association in September last, when I provisionally called it Monium; but for several reasons I now consider the name Victorium more appropriate.

The complicated scheme of fractionation carried on for so many years is illustrated in the accompanying diagram. This must be considered only as an indication of the methods employed, and not as an actual representation of every operation through which the material has passed. Crude yttria, from samarskite, gadolinite, cerite and other similar minerals, is the raw material. The first operation is to free it roughly from earths of the cerium group—an operation effected by taking advantage of the fact that the double sulphates of potassium and the yttrium metals are easily soluble in saturated potassium sulphate solution, while the corresponding double sulphates of the cerium group of metals are difficultly soluble.

After this preliminary treatment, the crude yttria is converted into nitrate, represented by the topmost circle on the diagram. The nitrate is exposed to heat until it fuses to a clear liquid, care being taken to distribute the heat uniformly through the mass. Presently the liquid mass commences to decompose, giving off red vapours. After this has proceeded for a little time, the fused mass is carefully poured into water, and the liquid well boiled. A white precipitate of basic nitrate forms, while the undecomposed nitrates remain in solution. These are separated by filtration—the precipitate going to the right and the solution to the left. The basic nitrate is dissolved in nitric acid, and the right and left solutions are then evaporated to dryness and fused as before. Partial decomposition by heat again divides each of these portions into two lots, soluble and insoluble. The soluble from the left-hand lot goes still further to the left, and its insoluble portion to the right. The soluble from the right-hand portion goes to the left, where it mixes with the insoluble from the other portion, while its insoluble portion goes still further to the right. This series of operations is continued for as long a time as the material will hold out.[2] From a description, the process seems to be more complicated than it really is, but a study of the diagram and the direction of the arrows makes it clear. The number of times this operation is performed varies with each lot of earth fractionated. The portions submitted to fusion rapidly diminish in quantity, and the

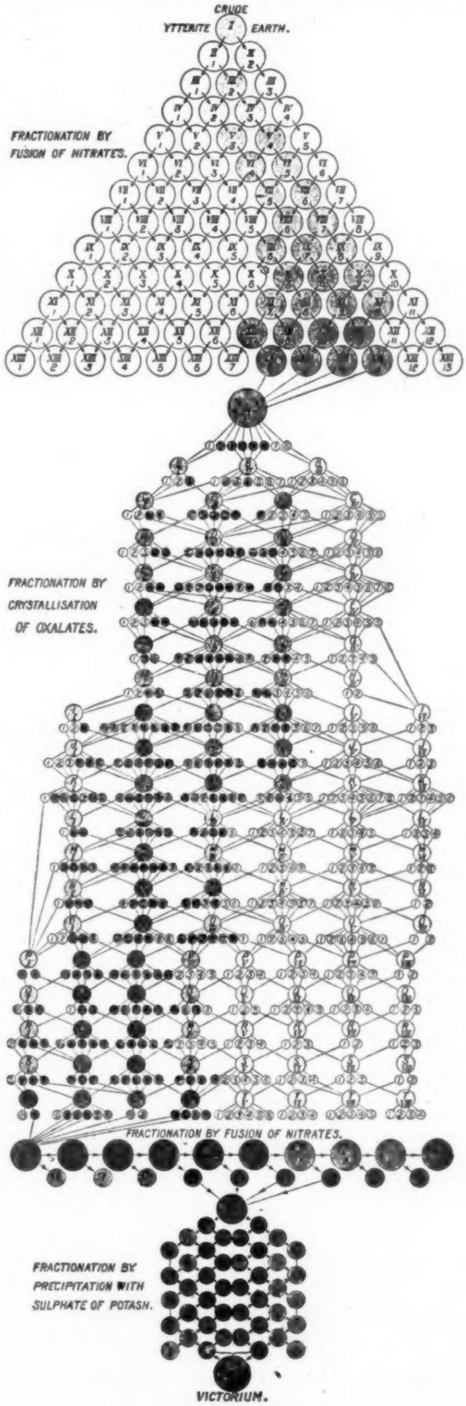

FIG. 1.

[1] A paper read before the Royal Society, May 4, by Sir William Crookes, F.R.S.

[2] "On the Methods of Chemical Fractionation," British Association, Birmingham Meeting, 1886; *Chemical News*, vol. liv. p. 131.

operation is continued until the material becomes too scanty.

The last horizontal line of fractions, spectroscopically examined in a radiant matter tube, shows differences in the visible spectrum. For many years I recorded these differences in coloured drawings, which have served on several occasions to illustrate papers before this Society.[1] In the year 1893 I commenced to record the differences between the various spectra by photographing them in a spectrograph having a complete quartz train, and since that time attention has chiefly been directed to the variations in the number, character and positions of the lines and bands in the ultra-violet spectrum; these are more striking than those which are visible, and as they are self-recording, results are more rapidly attained. A description of this instrument is given further on.

On placing the photographed spectra of one of the horizontal lines of earths in order, several differences are detected. One striking difference is seen in the behaviour of a group of lines in the ultra-violet. It is nearly absent in the end fractions, gradually becoming stronger towards the middle, and attaining a maximum in the fractions situate about two-thirds towards the right. This shows that at least three different bodies are present: one, the great bulk, having a nitrate difficult to decompose; another, whose nitrate is easiest to decompose; and a third body, occupying an intermediate position, whose nitrate decomposition occurs at temperatures between that required by the others, but nearer that of the nitrate easiest decomposed.

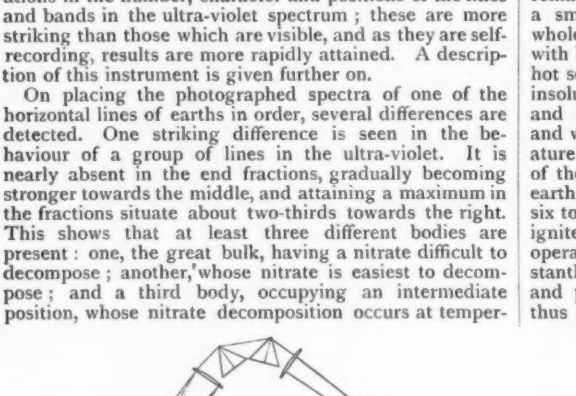

FIG. 2.

The above method of fractionation is not so effectual if more than two bodies are present. In that case the process fails, in any reasonable time, to yield practically pure specimens of more than two out of a group of closely allied earths. Thus, if there are three earths—say A, B and C—whose positions in reference to the chemical process employed are in the written order of sequence, we may get a specimen of A as nearly as we please free from B and C, and a specimen of C as nearly as we please free from A and B, but we cannot get a specimen of B practically free from A and C. The law seems to be that to obtain practically pure specimens of three closely allied earths, it is essential to have recourse to at least two different chemical processes. The mere continued repetition of the same process will not do, unless, indeed, the operations are repeated such a vast number of times as to make the approximate expressions no longer applicable, even though the substances are chemically very close.

For this and other reasons it is advisable to change the method of fractionation after one process has been in operation for some time. It is evident that any process of fusion, crystallisation or precipitation can only divide the mass of material into two parts, a soluble and an insoluble portion, crystals and mother liquor; and after a time a balance of affinities seems to be established, and further fractionation appears to do little good. It is better then to change the operation.

Following the diagrammatic scheme, the portions of earths containing most victorium are collected together and fractionated by the crystallisation of the oxalates from a solution strongly acidulated with nitric acid in the following manner:—

To a boiling acid solution of the nitrate a small quantity of hot solution of oxalic acid is added. The solution remains clear, and it is only after vigorous stirring that a small quantity of insoluble oxalate is formed. The whole is thrown on a hot-water filter and slightly washed with boiling water. To the boiling filtrate a fresh lot of hot solution of oxalic acid is added, and stirred till more insoluble oxalate comes down. This is again filtered off, and the operations of precipitating, stirring, filtering, and washing are repeated, always keeping the temperature as near the boiling point as possible, until the whole of the earths are precipitated. Generally the initial earth is divided by this method of fractionation into from six to twelve portions. Each of these oxalates is dried, ignited, dissolved in nitric acid, and the above-described operations repeated. Photo-spectroscopic tests are constantly taken during the progress of this fractionation, and portions are mixed together according to the data thus obtained, as shown on the diagram by the lines joining the fractions. The object being to avoid lateral spreading as much as possible, and, while concentrating the special line-giving earth, to prevent its too great diffusion over a large number of fractions. When the fractionation by the oxalate method has proceeded for a considerable time, the fractions rich in victorium are collected together and submitted to another mode of treatment.

These fractions are converted into nitrates, and a small quantity is thrown out by partial decomposition by heat, according to the method already described. The filtrate is evaporated to dryness and again fused, so as to throw out a little more. This operation is repeated as long as any soluble nitrate is left. Generally from six to twelve portions are thus obtained. These form a regular series, differing according to the stability of the nitrate under heat. On testing, the victorium is found to concentrate in the centre portions, being less easily decomposed than the earths of the cerium group, and more easily decomposed than those of the yttrium group.

The fractions rich in victorium are converted into sulphates and mixed with a hot saturated solution of potassium sulphate. The precipitate is dissolved in boiling water and mixed with a further quantity of solution of potassium sulphate. This produces a small quantity of a precipitate. The filtrate from the first precipitate is also mixed with fresh potassium sulphate, and the operations are repeated, mixing the centre solutions to one lot and the side solutions to another, as shown by the lines on the diagram. It is found on photo-spectroscopic examination that the earths thrown out on each side are poorest in victorium, whilst those in the middle are richest. After a time no further concentration is effected in this manner, all the earths that can be removed as being more or less soluble in potassium sulphate having been eliminated.

In thus describing the method of fractionation, my object has been not so much to give a description of the plan actually carried out in the laboratory—for the details have varied with each operation—but to give an intelligible idea of the general manner in which a very complicated operation is effected. In the diagram I am supposing that one particular substance, victorium, is to

[1] "On some New Elements in Gadolinite and Samarskite Detected Spectroscopically" (*Roy. Soc. Proc.*, No. 245, 1886 vol. xl. p. 502).

be separated, and I have endeavoured to show its migrations and gradual concentration as the work progresses, by tinting the fractions where it mostly would concentrate, the depth of tint representing the amount of concentration.

In the purest condition yet obtained victoria is an earth of a pale brown colour, easily soluble in acids. It is less basic than yttria and more basic than most of the earths of the terbia group. In chemical characters it differs in many respects from yttria. From a hot nitric acid solution victorium oxalate precipitates before yttrium oxalate and after terbium oxalate. On fractional precipitation with potassium sulphate the double sulphate of victorium and potassium is seen to be less soluble than the corresponding yttrium salt, and more soluble than the double sulphates of potassium and the terbium and cerium groups. Victorium nitrate is a little more easily decomposed by heat than yttrium nitrate, but the difference is not sufficient to make this reaction a good means of separating victorium and yttrium. Fusing the nitrates can, however, be employed advantageously to separate mixed victoria and yttria from the bulk of their associated earths.

On the assumption that the oxide has the composition Vc_2O_3, the atomic weight of victorium is apparently not far from 117.

The photographed phosphorescence spectrum of victoria consists of a pair of strong lines at about λ 3120 and 3117; other fainter lines are at 3219, 3064, and 3060. Frequently the pair at 3120 and 3117 merge into one, but occasionally I have seen them quite distinct. The presence or absence of other earths has much influence on the sharpness of lines in phosphorescent spectra, and it is probable that these lines will be sharp and distinct when victoria is obtained quite free from its associates.

The best material for phosphorescing in the radiant matter tube is not the earth itself, but the anhydrous sulphate formed by heating the earth with strong sulphuric acid and driving off the excess of acid at a red heat. The sulphate thus produced, probably also containing some basic sulphate, is powdered and introduced into a bulb tube furnished with a quartz window, and a pair of thick aluminium poles sealed into the glass with stout platinum wires. The tube is well exhausted, keeping the current from a good induction coil going all the time. The pumping and sparking must continue until the earth glows with a pure light free from haze or cloudiness, and continues so to glow during the passage of the current without deterioration. The exposure in the spectrograph usually occupies an hour.

I give a diagrammatic plan of the two-prism spectrograph used in this research. It is furnished with two quartz prisms, quartz lenses and condensers. The slit jaws are of quartz, cut and polished according to the method I described in the *Chemical News*, vol. lxxi. p. 175, April 11, 1895.

The prisms are made in two halves according to Cornu's plan, one half of each being right-handed and the other half left-handed. One of the lenses also is right-handed and the other left-handed. By this device the effect of double refraction is so completely neutralised that with a five-prism instrument it is impossible, under high magnifying power, to detect any duplication of the lines.

The lenses are each of 52 mm. diameter and 350 mm. focus. The focus of the least refrangible rays is longer than that of the most refrangible rays, and the sensitive film must therefore be set at an angle to get the extreme rays into focus at the same time. But this alone is not sufficient. The focal plane is not a flat surface, but is curved, and the film must therefore be curved,[1] and it is only when both these conditions are fulfilled that perfectly sharp images of spectral lines extending from the red to the high zinc line 2138·30 can be photographed on the same surface. Celluloid films are used, glass not being sufficiently flexible.

[1] *Chemical News*, vol. lxxii. p. 87, August 23, 1895; and vol. lxxiv. p. 259, November 27, 1896.

Using the middle position showing the whole spectrum on a plate, the angle is 40°, and the curvature is 190 mm. radius.

The condensers are of quartz, and are plano-cylindrical —one being double the focus of the other. The object of this, when spark-spectra are being photographed, is to concentrate on the slit a line instead of a point of light, as would be the case if ordinary lenses were used.

When photographing phosphorescent spectra—or, in fact, any spectra the wave-lengths of which are either unknown or require verification—I always photograph on the same film a standard spectrum, usually of an alloy of equal molecular weights of zinc, cadmium, tin and mercury. This forms a hard, somewhat malleable alloy, giving throughout the whole photographic region lines the wave-lengths of which are well known. The chief objection to this alloy is its volatility, the poles requiring frequent adjustment. Recently I have used pure iron for this purpose; this has the advantages of giving a great number of fine lines whose wave-lengths are accurately known, and not being very volatile, the poles do not rapidly wear away. If the poles are kept about 1 mm. apart, there is little or no interference from air lines.

The most simple method of applying the standard lines to an unknown spectrum is by the successive employment of two slightly overlapping diaphragms immediately behind the slit, one being used for the experimental and the other for the standard spectrum. In this way, without disturbing the instrument, the two spectra can be recorded on the plate one over the other; the overlap of 1 mm. being in the optical centre of the train. The resulting negative is then transferred to a micrometer measuring machine of special construction, having a screw of 1/100th of an inch pitch, and a means of accurately determining 1/1000th of its revolution, thus measuring directly to the 100/1000th of an inch. In this way, in a five-prism spectrograph having lenses 700 mm. focus, it is possible to determine wave-lengths of photographed lines to the sixth figure.

MATHEMATICS OF THE SPINNING-TOP.[1]

I.

"TO those who study the progress of exact science, the common spinning-top is a symbol of the labours and the perplexities of men who had successfully threaded the mazes of the planetary motions. The mathematicians of the last century, searching through nature for problems worthy of their analysis, found in the toy of their youth ample occupation for their highest mathematical powers.

"No illustration of astronomical precession can be devised more perfect than that presented by a properly balanced top, but yet the motion of rotation has intricacies far exceeding those of the theory of precession.

"Accordingly we find Euler and D'Alembert devoting their talent and their patience to the establishment of the laws of the rotation of solid bodies. Lagrange has incorporated his own analysis of the problem with his general treatment of mechanics; and since his time Poinsot has brought the subject under the power of a more searching analysis than that of the calculus, in which ideas take the place of symbols, and intelligible propositions supersede equations" (Maxwell—"Collected Works," I. p. 248).

Newton also cites the top as affording an experimental verification of his First Law of Motion—Lex. I. ". . .

[1] "Ueber die Theorie des Kreisels." F. Klein und A. Sommerfeld Heft i, ii. Pp. 196 and 197 to 512. (Leipzig: Teubner, 1897-8.)

Trochus, cujus partes cohaerendo perpetuo retrahunt sese a motibus rectilineis, non cessat rotari, nisi quatenus ab aere retardatur." We can translate *trochus* as a top, as well as a wheel or hoop.

But Newton lived too early to calculate any quantitative explanation of the theory of the top, and even his attempt at the simpler problem of precession was not a very great success. (Principia, lib. III., Prop. xxxix.) We had to wait for D'Alembert to straighten out the difficulties of first principles before arriving at an exact solution.

The key-note of the present treatise is found in § 2—"Analytische Darstellung der Drehungen um einen festen Punkt"—and in the bilinear relation in equation (5) on p. 25,

$$(1) \qquad \lambda = \frac{\alpha\Lambda + \beta}{\gamma\Lambda + \delta}, \text{ with } \alpha\delta - \beta\gamma = 1,$$

expressing analytically the displacement of a rigid body about a fixed point.

If x, y, z are the coordinates of a point with respect to axes fixed in space, and X, Y, Z of the same point with respect to axes fixed in the body,

$$(2) \qquad \lambda = \frac{x + yi}{r - z} = \frac{-r - z}{-x + yi},$$

while Λ is the same function of X, Y, Z; thus λ and Λ play the part of a stereographic representation of the point on the sphere of radius r with respect to the poles in which the sphere is intersected by the axes Oz and OZ.

Expressed by Euler's unsymmetrical angles θ, ϕ, ψ,

$$(3) \qquad \alpha = \cos \tfrac{1}{2}\theta e^{\frac{1}{2}(\phi+\psi)i}, \quad \beta = i \sin \tfrac{1}{2}\theta e^{-\frac{1}{2}(\phi-\psi)i}$$
$$\gamma = i \sin \tfrac{1}{2}\theta e^{\frac{1}{2}(\phi-\psi)i}, \quad \delta = \cos \tfrac{1}{2}\theta e^{-\frac{1}{2}(\phi+\psi)i},$$

satisfying

$$\alpha\delta = \cos^2 \tfrac{1}{2}\theta, \qquad \beta\gamma = -\sin^2 \tfrac{1}{2}\theta,$$

and

$$\alpha\delta - \beta\gamma = 1.$$

By putting

$$(4) \qquad \alpha = D + Ci, \qquad \beta = -B + Ai,$$
$$\gamma = B + Ai, \qquad \delta = D - Ci,$$

so that

$$A^2 + B^2 + C^2 + D^2 = 1,$$

the versor-quaternion

$$(5) \qquad Q = Ai + Bj + Ck + D$$

is obtained, which determines the displacement; this gives the authors an opportunity for an excursion into the Quaternion-Theory so far as required in their subject, and should delight the soul of Prof. Tait, always anxious to see more frequent applications of his favourite subject, to which allusion is made on p. 509.

In Maxwell's opinion, it is the introduction of the ideas, as distinguished from the operations and methods of Quaternions, which is valuable; and now we have McAulay's "Octonions" to assist, with plentiful illustrations of the dynamics of our subject.

The important use of the above bilinear relation between λ and Λ, for the treatment of the motion of a rotating body or a top, was pointed out by Prof. Klein in a lecture at Göttingen University in the winter-semester of 1895; the further development of the formulas was chosen by Prof. Klein as the subject of his Princeton Lectures in October 1896; and the present work is intended to be a complete presentation, with the collaboration of Prof. Sommerfeld.

Subsequent historical research, described on p. 511, has shown that the germs of similar ideas can be traced back through Hess (p. 429), Weierstrass (p. 511), up to Gauss in 1819. Gauss appears at the same time to have had some prophetic inspirations of the Quaternionic Theory, but as usual he carefully bottled up his ideas. It was said of the works of Friar Roger Bacon in the middle ages—"partim mutili direptis hinc inde quaternionibus facti, tam raro comparent, ut facilius sit Sibyllae folia colligere quam nomina librorum quos scripsit"—and the same might be said of Gauss's unpublished manuscripts, now at length to be edited completely by the Göttingen Academy of Sciences, under the direction of Prof. Klein, the present occupant of Gauss's chair. We think then that Prof. Klein is too generous in renouncing the priority of his discovery, considering that he was the first to make the invention really work, and that his precursors allowed the germs of the idea to pass from them unfertilised, not perceiving their real importance.

In the special case of the symmetrical top the functions α, β, γ, δ can be expressed by elliptic-theta functions; Prof. Klein calls them "multiplicative elliptic functions"; their form is given explicitly on p. 520, and now the solution is complete from the point of view of the mere mathematician of the school of—"Shut your eyes and write down equations."

"Mais il faut convenir que, dans toutes ces solutions on ne voit guère que des calculs, sans aucune image nette de la rotation du corps."

The authors, giving heed to this warning of Poinsot, devote the rest of the book to a careful examination and classification of the various cases which may occur; and also to what the ordinary mathematician in general so cordially detests, the working out and drawing in a diagram of some well-chosen numerical cases; only in this way is it possible to make sure of the accuracy and reality of the abstract formulas, and to lift mathematical science out of the arid collection of analytical results.

A first great requirement for the study of the movement of the top is an actual model, as shown on p. 1, or else a top such as that devised by Maxwell ("Collected Works," I. p. 248); sufficient rotation can be imparted by twirling the spindle by the finger; and a slight blow with the hand will give any desired variety to the pattern of the curve described by the end of the axle. A bicycle wheel, spinning in its ball bearings, supported in a fixed cup, would also serve the purpose.

As we have three independent constants at our disposal with the top, the number of possible cases is threefold infinite (∞^3); and so the choice of a numerical case is at first sight an embarrassing one in its variety.

In the book the constants employed are such that (p. 223)

$$(6) \qquad t = \int \frac{du}{\sqrt{U}}, \quad u = \cos\theta,$$

$$(7) \qquad \psi = \int \frac{n - Nu}{A(1 - u^2)} \frac{du}{\sqrt{U}}$$

$$(8) \qquad \phi = \int \frac{N - nu}{A(1 - u^2)} \frac{du}{\sqrt{U}} + N\left(\frac{1}{C} - \frac{1}{A}\right)t$$

$$(9) \qquad A^2U = (1 - u^2)(k - N^2 - 2APu) - (n - Nu)^2$$
$$= (1 - u^2)(k - n^2 - 2APu) - (N - nu)^2.$$

Here we must make the criticism that until p. 299 the mechanical interpretation of the quantities P, n, N is not very clearly defined so as to have their numerical values assigned in the C.G.S. system of units. Given the top we are to experiment with, we must first weigh it; denote the weight by W grammes; next measure the distance, h cm., between the C.G. and the point of support; then Wgh, dyne-cm., is the static moment denoted here by P, g denoting the acceleration of gravity (981) in cm./s.^{2}. The number A denotes, as usual, the moment of inertia, in g.cm.^{2}, of the top about an axis through its point perpendicular to its axis of figure; A can be determined experimentally by swinging the top as a plane or conical pendulum, and measuring the length of the equivalent pendulum, l cm., and the angular velocity m when swung without rotation as a conical pendulum of small aperture; then

$$l=\frac{A}{Wk},\quad A=Whl=\frac{Pl}{g},$$

and

$$m^2=\frac{g}{l}=\frac{Wgh}{A}=\frac{P}{A}.$$

So also C denotes, as usual, the moment of inertia, in g.cm.², about the axis of figure, and, with an angular velocity r rad./sec. about the axis of figure, $N = Cr$, the angular momentum about the axis; while n is the constant angular momentum round the vertical Oz.

In the discussion of the numerical cases, the authors start by taking a root $u = e$ of the cubic $U = 0$ as given, and then examining the various relations which subsist between N and n. But if one root of the cubic is known, the other two are determined by the solution of a quadratic, so that we may take all these roots as the three data of the question, and follow Darboux's method, as explained in the notes to Despeyrous' "Cours de Mécanique."

We may, for symmetry with Weirstrass' notation, denote the two extreme limits of θ by θ_2 and θ_3, so that $\cos\theta_2$ and $\cos\theta_3$ are two roots of the cubic U; the third root, being greater than unity, may be denoted by $\operatorname{ch}\theta_1$, and now

$$\begin{aligned}A^2U&=2AP(\operatorname{ch}\theta_1-\cos\theta)(\cos\theta_2-\cos\theta)(\cos\theta-\cos\theta_3)\\&=2APV\end{aligned}$$

suppose, with

$$\operatorname{ch}\theta_1>\cos\theta_2>\cos\theta>\cos\theta_3.$$

It is not clear how any simplicity is gained by considering negative as well as positive values of P (p. 248); this seems to introduce needless complication in the classification, as we can take P always positive, and measure the angles θ_2 and θ_3 from the upright vertical position of the top. There may be a slight disadvantage in the case of the spherical pendulum, in which the chief part of the motion takes place in the lower hemisphere, but the counterbalancing advantages of simplicity of classification prevail on the whole.

In Darboux's representation of the motion of the axis by means of the generating lines of a deformable hyperboloid, we take a focal ellipse, of which the ratio of the axes is equal to the modulus κ of the real period; the co-modulus κ' of the imaginary period ω' is thus the eccentricity of the focal ellipse; and

$$(10)\qquad \kappa^2=\frac{\cos\theta_2-\cos\theta_3}{\operatorname{ch}\theta_1-\cos\theta},\quad \kappa'^2=\frac{\operatorname{ch}\theta_1-\cos\theta_2}{\operatorname{ch}\theta_1-\cos\theta_3}.$$

The two generating lines HP and HP′ are placed in position at an angle θ_3 as tangents to the focal ellipse, and the deformable hyperboloid is completed in Henrici's manner by a number of other rods as tangent lines, knotted together at the points of crossing. With this model we can represent graphically the various constants of the problem.

Returning to the case considered by the authors, where θ_3, N, and n are given, we can select an arbitrary length OD, and measure off lengths HQ, HQ′ along two straight lines inclined at an angle θ_3, such that

$$(11)\qquad \frac{HQ}{OD}=\frac{n}{2\sqrt{AP}},\quad \frac{HQ'}{OD}=\frac{N}{2\sqrt{AP}};$$

and draw the perpendicular QO, Q′O to the lines meeting in O. We are now given the conjugate semi-diameters OH and OD, by which the ellipse can be described through H, and the confocal ellipse, touching HQ and HQ′, is the focal ellipse of the deformable hyperboloid.

On this diagram

$$(12)\qquad \cos\theta_3=\frac{OH^2-AB^2}{OD^2},\quad \sin\theta_3=2\frac{OS\,.\,OM}{OD^2},$$

$$\cos\theta_2=\frac{OH^2-OS^2}{OD^2},\quad \sin\theta_2=2\frac{OS\,.\,ON}{OD^2},$$

$$\operatorname{ch}\theta_1=\frac{OH^2+OS^2}{OD^2},\quad \operatorname{sh}\theta_1=2\frac{OQ\,.\,HP}{OD^2};$$

$$\frac{k}{2AP}=\frac{3OH^2-AB^2}{OD^2}=\operatorname{ch}\theta_1+\cos\theta_2+\cos\theta_3.$$

If θ_1, θ_2, θ_3 are given, then

$$e^{\theta_1}=\frac{HS'}{HS},\ \text{while}\ \frac{\operatorname{ch}\theta_1}{\cos\theta_2}=\frac{OH^2+OS^2}{OH^2-OS^2},$$

from which, when the focal ellipse is drawn, the position of H and the tangents HP, HP′ can be drawn.

The angle AOQ is the amplitude function of a certain fraction fK' of Jacobi's quarter period K′, with respect to the co-modulus κ', the eccentricity of the focal ellipse; denoting AOQ by ω, then, in Legendre's notation,

$$(13)\qquad F\omega=fK',$$

whence the fraction f can be determined from his tables; so also the fraction f' for AOQ′.

In connection with the dynamical interpretation there is an important point L in the tangent HP, such that, in Jacobi's notation for the Zeta-function,

$$(14)\qquad \begin{gathered}QL=OAZfK'\\ LV,\ LT,\ LP=OA\,(zs,\ zc,\ zd)fK'.\end{gathered}$$

Expressed in Legendre's notation

$$ZfK'=E\omega-fE,$$

from which the position of L can be calculated by Legendre's Tables; and now a reduction of the elliptic integrals of the third kind in (7) will show that the apsidal angle

$$(15)\qquad \Psi=\frac{HL}{OA}K+\tfrac{1}{2}f\pi.$$

Integral (6) for the time t gives

$$(16)\qquad mt=\int\frac{du}{\sqrt{2V}}=\frac{F\phi}{\sqrt{\tfrac{1}{2}(\operatorname{ch}\theta_1-\cos\theta_3)}}=\frac{OD}{OA}F\phi,$$

where

$$(17)\qquad \cos\theta=\cos\theta_3\cos^2\phi+\cos\theta_2\sin^2\phi;$$

a different use of ϕ to that employed in (8).

Thus if T is the time taken by the axis to swing between the extreme inclinations θ_3 and θ_2,

$$(18)\qquad mT=\frac{OD}{OA}K.$$

When H is at T, $N=n$, and the rosette curves described by Prof. Klein are obtained, in which the axis passes periodically through the highest vertical position, shown in Figs. 55, 56, 57. When H is at V, $N=n$ again, but now the axis describes an intermediate path, never becoming vertical. When H is at P, $N=-n$, and $\cos\theta_3=-1$; the axis now describes a new series of rosette curves, all passing through the lowest vertical position. These rosette curves are shown in one of Mr. T. I. Dewar's stereoscopic diagrams.

If we make $\kappa=1$, the focal ellipse becomes circular, and now $N=n=2\sqrt{AP}\cos\frac{1}{2}\theta_3$, and the axis reaches the highest vertical position asymptotically, the case represented in Fig. 58; and the hyperboloid shuts up into the axis, like a deformable napkin-ring.

Having settled upon a certain modulus κ, and a certain fraction f, which gives the tangent TPQ of the focal ellipse, we can examine the variety of cases which arise by taking different positions of H on this tangent.

In the spherical pendulum $N=0$, so that H must be placed on the pedal of the ellipse with respect to the centre O; and now

$$(19)\qquad \cos\theta_3=-\frac{OQ}{OH}=-\frac{\operatorname{dn}fK'}{\operatorname{dn}f'K'};$$

and similarly

$$\cos\theta_2=-\frac{\operatorname{cn}fK'}{\operatorname{cn}f'K'},\quad \operatorname{ch}\theta_1=\frac{\operatorname{sn}fK'}{\operatorname{sn}f'K'}.$$

When H is on the tangent at B or B′, the curve described by points on the axis have cusps; when H lies between these points, the curves are looped, and the associated herpolhode has points of inflexion.

In steady precessional motion $\kappa=0$, and the focal ellipse coalesces with the line SS′; now $f=0$ and $K=\frac{1}{2}\pi$, so that the apsidal angle

$$\Psi=\frac{HS}{OS}\tfrac{1}{2}\pi. \tag{20}$$

If μ denotes the constant angular velocity of precession,

$$\mu T=\Psi,\ mT=\frac{OD}{OS}\tfrac{1}{2}\pi,$$

so that

$$\frac{\mu}{m}=\frac{HS}{OD}. \tag{21}$$

The steady motion relations

$$P=N\mu-A\mu^2\cos\alpha,\ n=A\mu\sin^2\alpha+N\cos\alpha, \tag{22}$$

when α denotes, instead of θ_3, the constant inclination of the axis to the vertical, will be found, on eliminating μ, to be equivalent to the geometrical relation

$$OQ\,.\,OQ'=\tfrac{1}{4}OD^2\sin^2\alpha, \tag{23}$$

so that O lies on a certain hyperbola, $xy=\frac{1}{4}OD^2$, referred to HQ, HQ′ the asymptotes as axes; thus given N and α, a geometrical construction will determine the solution of the problem.

Having selected OD arbitrarily, the hyperbola is drawn, and then having laid off HQ′ to scale, draw Q′O at right angles to the asymptote HQ′ to meet the hyperbola in O; the tangent to the hyperbola at O will meet the asymptotes in S and S′.

The second solution will depend on the second point O′ in which Q′O cuts the hyperbola. To realise the state of motion shown in Fig. 28, the point O on the hyperbola must be close to the asymptote.

It is very desirable that a penultimate case of this nature should be worked out completely. We have the requisite analysis for the calculation of the algebraical case when there are 22 cusps, but the work would require the arithmetical courage of a Dewar, now unfortunately no longer available.

Supposing that in consequence of the friction of the pivot the motion has steadied down to uniform precession, then a $\begin{pmatrix}\text{following}\\\text{heading}\end{pmatrix}$ tap on the spindle, to $\begin{pmatrix}\text{hurry}\\\text{delay}\end{pmatrix}$ the precession makes O move along OQ and produces a focal $\begin{pmatrix}\text{ellipse}\\\text{hyperbola}\end{pmatrix}$ and the axis $\begin{pmatrix}\text{rises}\\\text{falls}\end{pmatrix}$.

A tap in the vertical plane makes O start out normally to the plane, and the lines HQ, HQ′ are now generating lines of Darboux's hyperboloid, in an intermediate position.

Once the limits θ_2 and θ_3 are assigned, and the corresponding apsidal angle Ψ, a regular curve satisfying these conditions drawn empirically will give an idea of the complete curve described by the axis.

But if it is desired to plot a number of intermediate points from tabular matter of the elliptic functions, we are baffled by the mixture of the real and imaginary arguments of the theta-functions required in the calculation of ψ and ϕ, although θ is readily calculated by equation (17). A courageous attempt at this computation is made in IV. 8, by Herr Blumenthal, but the hidden rocks of error are numerous and plentiful enough to make this procedure dangerous. If the calculation of a number of guiding points between the extreme points of a branch of the spherical curve is required, we had better utilise Jacobi's theorem, that the curve described in a horizontal plane round the vertical OG by the extremity of the vector OH of resultant angular momentum is a Poinsot herpolhode; and having plotted this herpolhode, the vertical plane defined by ψ may be drawn perpendicular to the tangent HK of the herpolhode, while a simple relation of the form

$$\cos\theta+2\frac{OH^2}{OD^2}=\frac{k}{2AP}=\operatorname{ch}\theta_1+\cos\theta_2+\cos\theta_3, \tag{24}$$

will give the corresponding value of θ, and hence the spherical curve, or its projection, orthographic or stereographic, can be plotted to any desired accuracy.

This theorem of Jacobi is almost self-evident when interpreted by means of Darboux's representation of the motion by the deformable articulated hyperboloid.

In this method the rod OG is held in the vertical position, and the point H is guided round the herpolhode; and then OG, connected by the articulation, will imitate the movement of the axis of the top; for a quadric surface can be drawn through H coaxial with the articulated hyperboloid, and normal to HP at H, and the squares of the semi-axes of this quadric will be, by a well-known theorem of solid geometry

$$HQ\,.\,HV,\ HQ\,.\,HT,\ HQ\,.\,HP, \tag{25}$$

with proper attention to sign; and these being fixed lengths, the quadric is a fixed quadric.

Its equation may be written

$$Ax^2+By^2+Cz^2=D\delta^2, \tag{26}$$

with

$$\delta=HQ;\ \frac{D}{A}=\frac{HV}{HQ},\ \frac{D}{B}=\frac{HT}{HQ},\ \frac{D}{C}=\frac{HP}{HQ}(\pm), \tag{27}$$

the $\pm$ sign being taken according as Q and V, T, P are on the $\begin{pmatrix}\text{same}\\\text{opposite}\end{pmatrix}$ sides of H.

An accent will serve to distinguish the case where a fixed quadric rolls on the plane through H perpendicular to HP′; and now we see why the same polhode described by H with respect to the axis of the articulated hyperboloid has associated with it two distinct herpolhodes.

(*To be continued.*)

LIFE-HISTORY OF THE PARASITES OF MALARIA.

THE parasites which cause malarial fevers in human beings belong to a very homogeneous group, other species of which are found in certain bats and birds. The life-history of the three species of this group which have been completely studied is as follows. The youngest parasites exist as amœbulæ or myxopods within the red blood corpuscles of the vertebrate host. Each amœbula possesses a nucleus and nucleolus; and its movements vary in extent and rapidity with the species, but, in the case of birds, never encroach upon the nucleus of the corpuscle. The amœbulæ increase in size; and, as they do so, tend to lose their movements and to accumulate in their ectoplasm certain black granules, the pigment or melanin, which are the product of assimilation of the hæmoglobin of the corpuscle. In from one to several days the parasites reach their highest development within the vertebrate host, and become either (*a*) sporocytes or (*b*) gametocytes.

The sporocytes, which are produced asexually, contain spores which vary in number according to the species. The spores do not possess any appreciable cell-wall. When they are mature the corpuscle which contains them bursts and allows them to fall into the serum. They then attach themselves to fresh blood corpuscles, and continue the propagation of the parasites indefinitely in the vertebrate host. The residuum of the sporocyte, consisting chiefly of the pigment, is taken up by the phagocytes of the host for eventual disposal in the host.

The gametocytes, while in the blood of the vertebrate host, are still contained in the shell of the corpuscle.

In some species their general form and appearance is very like that of the sporocytes before the spores are differentiated; in another, however, they possess a special crescentic form. They continue to circulate in the blood for some days, or even weeks (according to the species), without change; but when they are drawn into the alimentary canal of certain suctorial insects, they undergo further development. In a few minutes after finding themselves in their new position, they break from the enclosing corpuscle by a kind of expansion, swell up slightly, and then commence their sexual functions. The male gametocytes emit a variable number of microgametes, which escape into the serum of the ingested blood, leaving behind a residuum consisting chiefly of pigment—as in the case of the sporocytes. The individual microgametes are delicate but very active filaments, consisting chiefly of chromatin, and sometimes seen to have a slight swelling at one point of their length—in the middle, when free, according to my observations. After escape from the male gametocyte, the microgametes seek the female gametocytes, which consist each of a single motionless macrogamete. One microgamete now enters bodily into a macrogamete and fertilises it, producing a zygote.

The further history of the zygote has been traced, as regards three species of this group of parasites, in certain kinds of mosquitoes. After being fertilised, it acquires the power of escaping the phagocytes of the ingested blood which surround it, of working its way through the mass of blood, of passing through the thickness of the stomach (middle intestine) of the mosquito, and of affixing itself to the outer surface of the organ. Here the zygotes are first found as oval cells about 8-10 μ in diameter. They still contain the granules of pigment which the macrogametes possessed before fertilisation. Growing rapidly, they soon acquire a capsule, and begin to protrude into the body-cavity of the mosquito. From an early period the nucleus divides into a number of portions—zygotomeres—each containing a fragment of chromatin. As growth advances, the zygotomeres become spherical blastophores, bearing each a large number of delicate, filamentous zygotoblasts on their external surface—each zygotoblast being affixed to the surface of the blastophore by one extremity. As maturity is approached the zygote, though still attached to the outer wall of the insect's stomach, protrudes freely into the body-cavity; its pigment tends to disappear; and lastly, the blastophores disappear, leaving the capsule packed with thousands of zygotoblasts. Maturity is reached in from one to three weeks, according to the external temperature, when the zygote reaches a size of 60 μ or more. The capsule then ruptures, pouring the zygotoblasts into the insect's blood.

The zygotoblasts are now seen to be delicate flagellulæ or mastigopods, about 12-16 μ in length, with the chromatin and one or two unstained areas in the middle, and two opposite tapering flagella. I have not, however, observed any notable movement in them, probably on account of the necessary dissecting medium. After being discharged into the insect's blood, these bodies are carried away by the current into all parts of the tissues, and finally effect an entry into the large grape-like cells of the salivary gland—especially the cells of the short middle lobe—where they accumulate in very large numbers. From the cells of this gland they pass into the duct which runs to the extremity of the middle stylet, the lingula, and thence escape during haustellation into the blood of a new vertebrate host. Here, it must be supposed, the flagellulæ attack the corpuscles and become the intra-corpuscular amœbulæ with which we started.

Four points require notice. (1) There are reasons for supposing that the gametocytes are or may be produced by the conjugation of two or more amœbulæ in one corpuscle. (2) The gametocytes of several species show, after escape from the corpuscle, one or more minute spherical bodies attached to their margin; which I assume to represent polar bodies. (3) The young zygote of at least one species (of crows) possesses, shortly after fertilisation, somewhat active powers of locomotion. (4) The mature zygotes of at least two species often contain large, brown, thick-shelled, cylindrical bodies, the nature of which has not yet been elucidated, and which may be parasitic fungi of the mosquito.

A brief history of how these facts came to be ascertained may be of interest. Laveran discovered the human parasites in 1880; and Danilewsky those of birds, some years later. Golgi established the law of endogenous reproduction by means of spores in 1885; and noted the differences in the various human species. Later, several Italian writers observed the distinction between the sporocytes and the gametocytes, but failed to understand the nature and object of these latter forms. The escape of the microgametes can be witnessed *in vitro;* and a dispute now arose as to the meaning of these bodies. Antolisei, Grassi, Bignami, Labbé and others held that they are products of death and degeneration *in vitro*. On the other hand, Laveran, Danilewsky and Mannaberg supposed them to represent the highest development of the organisms, while the last writer thought that they were meant for an exogenous saprophytic existence—without, however, suggesting the mode of their escape. In 1894 Manson concluded that the gametocytes are intended to continue the species outside the vertebrate host; and that they escape into the stomach of a suctorial insect, and then give rise to flagellulæ—as he considered the microgametes to be—which in turn develop in the tissues of the insect. He founded these views chiefly on the fact that the microgametes escape from the gametocyte only after abstraction of the blood from the vertebrate host. Laveran had already surmised that the mosquito is the alternative host of the human parasites; and Manson now claimed the mosquito as the suctorial insect referred to.

Early in 1895 I attacked the subject experimentally in India, on the lines laid down by Manson. Owing to the difficulty of the investigation and to the use of wrong species of mosquitoes, I failed for more than two years in reaching positive results. In August 1897, however, on employing two species of Anopheles fed on patients containing the crescentic gametocytes, I found the zygotes in various stages of growth attached to the wall of the insect's stomach. My work was now interrupted; but next year I succeeded in following out the life-history of the zygotes of one of the parasites of birds in their development in *Culex pipiens*. The zygotoblasts were found in the salivary glands of the mosquitoes; and lastly, in July 1898, I succeeded in infecting a large number of healthy birds by the bites of infected insects.

Meanwhile (1898) MacCallum had discovered the true nature of the microgametes by actually witnessing the sexual act *in vitro*, while Metchnikoff, and Simond had found microgamates also in *Coccidium oviforme* and *C. salimandrae;* so that the exact relationship between the gametocytes in the blood of the vertebrate (intermediary) hosts and the zygotes found by me in the mosquitoes (definitive hosts) became quite evident.

My results were published by Manson in August 1898, and were confirmed by Daniels, of the Malaria Commission of the Royal Society, in December. It was now easy to extend my observations to other species of the group, a work, however, which I was unable to undertake. In November and December 1898, Grassi, Bignami and Bastianelli cultivated two of the human parasites in a third species of Anopheles, *A. claviger*, Fabr., and succeeded in infecting several healthy persons. Shortly

afterwards Koch confirmed the principal observations which had been made.

If we can exterminate the malaria-bearing species of mosquito in a locality, we may expect to prevent the propagation of the parasites there; I trust, therefore, that these investigations will not remain without practical results.

It may be useful to add a note regarding the somewhat confused matter of the classification and nomenclature of the various species. I divide those of men and birds into two genera, named as follows:—

Family: HÆMAMŒBIDÆ, Wasielewski.

Genus I. *Haemamoeba*, Grassi and Feletti. *The mature gametocytes are similar in form to the mature sporocytes before the spores have been differentiated.*

Species I: *Haemamoeba Danilewskii*, Grassi and Feletti. Syn.: *Laverania Danilewskii*, Grassi and Feletti, in part; *Halteridium Danilewskii*, Labbé; &c. Several varieties—possibly distinct species. Parasite of pigeons, jays, crows, &c.

Species 2: *Haemamoeba relicta*, Grassi and Feletti. Syn.: *Haemamoeba relicta* + *H. subpraecox* + *H. subimmaculata*, Grassi and Feletti; *Proteosoma Grassii*, Labbé; &c. Parasite of sparrows, larks, &c.

Species 3: *Haemamoeba malariae*, Grassi and Feletti. Syn.: *Haemamoeba Laverani*, Labbé, in part. Parasite of quartan fever of man.

Species 4: *Haemamoeba vivax*, Grassi and Feletti. Syn.: *Haemamoeba Laverani*, Labbé, in part. Parasite of tertian fever of man.

Genus II: *Haemomenas*, gen. nov. Syn.: *Laverania*, in part + *Haemamoeba*, in part, Grassi and Feletti. *The gametocytes have a special crescentic form.*

Species: *Haemomenas praecox*, Grassi and Feletti. Syn.: *Haemamoeba praecox* + *H. immaculata* + *Laverania malariae*, Grassi and Feletti; *Haemamoeba Laverani*, Labbé, in part; &c. Several varieties—possibly distinct species. Parasite of the irregular, remittent, pernicious or æstivo-autumnal fever of man.

The two species lately discovered by Dionisi in bats appear to belong, one to one genus, and the other to the other genus. Two species described in frogs do not contain pigment, and require further study. Grassi and Feletti's arrangement is very confused, chiefly on account of their combining *H. Danilewskii* with the crescentic gametocytes of *H. praecox* in a separate genus, *Laverania*. Labbé admits only one human species, and yet erects two genera for the avian species. The double spore-clusters of *H. Danilewskii*, on which he lays much stress, are not always found, and are at the best due, I think, merely to the presence of the nucleus compressing so large a parasite. There is little to justify generic differences between the four species of *Haemamoeba*. On the other hand, the last species given above is sharply divided from the rest.

The zygotes of three species have been found to develop in mosquitoes as follows:—

Haemamoeba relicta in *Culex pipiens*.

Haemamoeba vivax in *Anopheles claviger*.

Haemomenas praecox in two undetermined species of Anopheles in India, and in *Anopheles claviger* in Italy.

The development is the same in all, but slight differences in details have been noticed between *H. vivax* and *H. falcipara* in the mosquito.

The terminology employed above has been adopted in consultation with Prof. Herdman, F.R.S. Some of it has already been used in this connection by Mesnil, and by Grassi and Dionisi. Nuttall has recently given a very full account of the subject in the *Centralblatt für Bakteriologie*.

RONALD ROSS.

SCIENCE AND EDUCATION.

TWENTY years have passed since Huxley said, at the opening of Mason College, Birmingham: "How often have we not been told that the study of physical science is incompetent to confer culture; that it touches none of the higher problems of life; and what is worse, that the continual devotion to scientific studies tends to generate a narrow and bigoted belief in the applicability of scientific methods to the search after truth of all kinds? How frequently one has reason to observe that no reply to a troublesome argument tells so well as calling its author a 'mere scientific specialist.' And, I am afraid it is not permissible to speak of this form of opposition to scientific education in the past tense." . . .

The exact applicability of these words in this year of grace is as good an example of the slowness of progress as could be wished. It is still urged almost as persistently as ever, and with the weight of university authority, that the only avenue to culture is by way of classics and the humanities. Has nothing come of the example of men like Huxley, Darwin, and the host of other widely-read, and deeply-educated, students of nature who, having borne their testimony, have gone over to the great majority?

These thoughts follow naturally from recent events in connection with the discussions and suggestions anent the constitution of the proposed Board of Education. The retirement of Sir John Donnelly from the secretaryship of the Science and Art Department led to the appointment of Sir George Kekewich to the vacant position, and for the future he will rule educational affairs both at South Kensington and Whitehall. In addition, two principal assistant secretaries were appointed, one for each of the departments referred to. These arrangements have disturbed the minds of the champions of that ill-defined section of educational work known as secondary education. After due representations Sir John Gorst stated, in the House of Commons, in reply to a question of Prof. Jebb, that a third official will be later appointed as assistant secretary for secondary education. This decision resulted in a correspondence which has brought to mind Huxley's addresses on education.

When a distinguished scholar and, on most subjects, broad-minded thinker, as Sir William Anson is, expresses himself in words like the following, which are taken from a letter in the *Times* of July 27, some sort of protest seems absolutely necessary.

"The attitude of those who are interested in secondary education, properly so-called, as distinct from elementary education on the one hand and instruction in science and art or technical education on the other."

"Scientific teaching alone will not produce the educated man, and the scientific expert may not be the best judge of the value of literary and historical studies, or of the respective parts which science and the humanities should play, even in an education which is mainly scientific."

"It is very important if the educational forces are to be brought into line, if the youth of the country are not merely to acquire some useful knowledge, but to become educated men—that where secondary education is given at all it should be given well, and that wherever it is given some one should watch over its interests and see that in the competition of humane and technical studies a due proportion is observed."

A number of unjustifiable conclusions may be derived from this letter; and it is therefore worth while to deal with a few of the points in it.

In the first place, it is tacitly assumed that some kind of secondary education exists in which instruction neither in science nor in art is given. The synonymous use of technical education and instruction in science and art must be passed over, though it provides a suggestive

index to the views of persons who are ever ready to pass judgment upon the educating capabilities of science and art. A course of instruction which ignores science and gives the cold shoulder to art is in one sense "secondary," but in no respect can it be called education. "Secondary education, properly so called," cannot exist distinct from "instruction in science and art." In fact, it is a little difficult to imagine what meaning Sir William Anson is intending to express. It would seem that he wishes to draw a distinction between the education offered in institutions of the grammar school type and those in which the curricula are at present directly governed by the Department of Science and Art. But it is a noteworthy circumstance that quite a number of old grammar schools provide, side by side with their classical work, classes in science which are actually subsidised by the much maligned department at South Kensington. And what is even more strange, judged from the point of view of Sir William Anson's letter, quite a number of these old grammar schools are also what is technically called "organised schools of science," which being interpreted, means that their time tables are modelled upon the regulations laid down in the Science and Art Directory, since they must be approved by the Inspector of the Department.

But the inference of the second quotation is of a more perverted type. "Scientific teaching alone will not produce the educated man," &c. Here again, something different from what is actually said is meant. Of course, Sir William Anson would agree that no teaching which is not scientific will do much towards educating anybody. As he himself said in a debate in the House of Commons on June 26, teachers should be taught how to teach, that is, should have "scientific" teaching explained to them. What is doubtless meant in the *Times* letter is, that instruction in natural science alone will not produce the educated man.

With this statement every man of science will agree; but neither will instruction in any single branch of human knowledge by itself educate. It would be just about as wise to attempt to educate a boy without introducing him to the beauties of our own incomparable national literature or that of some other great country, as it would to attempt to make him a cultured man and at the same time keep him ignorant of his place in the scheme of the universe and of the grandeur and beauty of the laws which govern things material. Culture is not the narrow business which the products of an exclusively classical training would have the world believe. Those authorities who claim for themselves alone the positions of priests in the temple of culture, are anachronisms—they should have lived in the Middle Ages. No education is worthy of the name which fails to endow its possessor with a sufficient breadth of view to give him a charitable demeanour towards every department of mental activity, and most of all to that wonderful accumulation of scientific knowledge to which we owe all that is best in life at the end of the nineteenth century. The man of science is as devout an admirer of literature, whether classical or modern, as any man. He is as ready with a profound admiration for the unique creations of the highest art, whether pictorial, musical, dramatic or what not, as any man. But he does claim that his goddess, science, is as worthy of attention as any other, and he has a right to expect that the reverence which he willingly extends to other deities shall similarly be shown by those who approach his particular shrine.

"The scientific expert may not be the best judge of the value of literary and historical studies or of the respective parts which science and the humanities should play, even in an education which is mainly scientific." So writes Sir William Anson. Possibly not, is the natural answer. But it is just as true that the classical (or historical) expert may not be the best judge of the value of scientific and artistic studies, or of the respective parts which the humanities and science should play, even in an education which is mainly classical. This is only a verbose way of saying that no individual can know everything. There is just as good reason, to say nothing stronger, for giving the control of the classical part of secondary education into the hands of a widely cultured and eminent man of science as there is for making a similarly great classical authority responsible for the government of the teaching of science or art. We surmise that no good will come of special pleading of this specious kind.

With the third quotation from Sir William Anson's letter given above there can be no disagreement if it is rightly understood. No man of science would imagine the youth of the country to be educated who had merely acquired some useful knowledge. We all want our secondary education to be given well. But let us look facts in the face. It is possible to spend twenty years in studying classics and to remain uneducated. We may become familiar with the histories of all the nations of the earth and be as far from culture as when we started the study. The secrets of nature may all have been laid bare before our understanding eyes, and yet we may still dwell with the Philistines. Let it be thoroughly understood that education and culture are greater than history, greater than classics, greater than science, but include them all, each in its proper place, and these narrow-minded bickerings as to the place of this or that subject of study will become things unknown.

One more reference to Huxley will define the scope of education from the point of view of a representative man of science. Speaking in 1868 to the working men of South London, Huxley defined the well-educated man: "That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself."

THE UNIVERSITY OF LONDON.

THE supplementary vote of 65,000*l.* required in connection with the housing of the University of London in the Imperial Institute building at South Kensington was agreed to by the House of Commons on Monday.

A portion of the western end of the building is to be assigned to the Institute free of rent, and the eastern and central portion of the building will form the new home of the London University. The space which will be given to the University in the building will be far greater than was now enjoyed by that body. In consideration for the transfer of the lease to the Office of Works, the Government will provide funds sufficient to pay off the existing mortgage of 40,000*l.* and discharge the floating debt of 15,000*l.* In addition to the cost of structural alterations, estimated at 7000*l.*, the vote included 3000*l.* for the maintenance and repair of the buildings and for the purchase of the necessary furniture.

The Treasury Minute, dated July 13, containing particulars of the transfer, is reprinted below:—

The First Lord and the Chancellor of the Exchequer recall the attention of the Board to the question of the future housing of the University of London in the present Imperial Institute buildings, and they refer to the Board's Minute of February 16 last.

In pursuance of that Minute, conferences have been held between representatives of the University, of the Institute and of Her Majesty's Government, which have resulted in definite arrangements, subject only to adjustment on points of detail. The report of the Government representatives is now before the Board together with correspondence and memoranda connected with the subject.

Before proceeding to state the conclusions as affecting the University, the First Lord and Chancellor of the Exchequer desire to refer in general terms to the arrangements which have been made by Her Majesty's Government with the governing body of the Institute respecting the whole group of buildings now in their possession.

They are as follows :—

(1) The lease under which the buildings are held from the Commissioners for the Exhibition of 1851 will be transferred to the Commissioners of Works as representing the Crown, and the latter Commission will thereupon become responsible for maintenance, rates, custody and protection of the buildings. The Commissioners for the Exhibition of 1851 have assented to this arrangement.

(2) An agreed portion of the buildings will be assigned for the use of the Institute, free of rent, but with the responsibility for internal maintenance and repairs of that portion.

(3) The cost of removing the Institute from the portions of the buildings which they will surrender, including the necessary structural alterations, will be paid by Government.

(4) In consideration of the transfer of the lease, Government will provide funds sufficient to pay off the existing mortgage of 40,000*l.* on the building, and also to discharge a floating debt of the Institute, not to exceed in all 15,000*l.*

These arrangements will enable Her Majesty's Government to offer to the London University accommodation in the building which may roughly be described as follows :—

The eastern and central portions of the main block, including the principal entrance, vestibule and staircase, and the Great Hall ; subject to occasional use by the Institute of certain portions of the central block when not required by the University, under regulations approved by the Chancellor of the University, and subject also to certain reservations in favour of the Government of India.

Also a portion of the upper floor of the inner block of building running east and west ; and the temporary structure now standing in the South-Eastern Court.

This offer, which provides much more space than the present building in Burlington Gardens, has been accepted by the Senate of the University.

The principal structural alterations and adaptations required are—

(*a*) For the University—the provision of suitable lavatories and refreshment accommodation for candidates, and, if desired, the construction of a separate staircase giving access for candidates to examination rooms on the upper floors :

(*b*) For the Institute—the construction of a new entrance at the western end of the main block, the provision of new library and dining accommodation for Fellows, and the redecoration of rooms to which some of the services (Colonial and Indian) now provided in the eastern portion of the building will be transferred.

The University will occupy its new quarters under conditions substantially the same as those under which it now occupies the building in Burlington Gardens.

As regards accommodation for the practical examinations of the University in physics and chemistry, it has been agreed that this shall be provided in the new buildings about to be erected for the Royal College of Science, subject to arrangement between the two bodies as to dates of user. The Science and Art Department will take charge of, and keep in order, the instruments and appliances for the examinations.

The formal transfer of the lease will be carried into effect by the Solicitor to this Board ; and the First Commissioner of Works should report at once as to the cost of the necessary works, as to arrangements for custody of the building, and as to the terms upon which the Institute should become tenants of the part of the building to be assigned to them.

The formal concurrence of the University and of the Institute, subject to settlement of details, has been obtained.

My Lords concur. They take note of the statements of the First Lord and Chancellor of the Exchequer, and desire that the necessary steps may be taken for carrying them into effect.

NOTES.

THE seventy-first meeting of German Naturalists and Physicians will be held at Munich on September 17–23. According to the final programme of arrangements, the two general meetings will be held in the Königliche Hoftheater. At the opening meeting, on Monday, September 18, the following lectures will be delivered :—Dr. Nansen, on his journey towards the North Pole, and its results ; Prof. v. Bergmann, Berlin, on the use of radiography to surgery ; and Prof. Förster, Berlin, on the progress of astronomical thought during the past hundred years. At the second general meeting, on Friday, September 22, Prof. Birch-Hirschfeld, Leipzig, will lecture on science in relation to medicine ; Prof. Boltzmann, Vienna, on the development of the methods of theoretical physics in modern times ; and Prof. Klemperer, Berlin, on Liebig and medicine. There will be thirty-seven sections for scientific papers, seventeen being devoted to purely scientific subjects, and twenty to medicine. In a general meeting of the scientific sections Prof. Chun, Leipzig, will give an account of the results of the German Deep Sea expedition. A report will be presented by Prof. Bauschinger (Berlin), Prof. Mehmke (Stuttgart), and Prof. Schülke (Osterode) on the question of the decimal division of time and angle—a subject which will also be dealt with in a congress to be held in connection with the Paris Exposition next year. In a general meeting of the medical sections, Prof. Marchand (Marburg) and Prof. Rabl (Prague) will report upon the relation of pathological anatomy and general pathology to embryology, with special reference to the cell theory.

HITHERTO the overhead system of conveying electrical energy for driving tramcars has been the one most commonly adopted. The London County Council has, however, just decided to test underground systems of electric traction upon one of their lines. The recommendation of the Highways Committee, adopted on Tuesday, is as follows :—"That the estimate submitted by the Finance Committee for 10,000*l.* be approved ; and that the Council do authorise the expenditure by the Highways Committee of that sum for the preparation of plans, specifications, and estimates, and other preliminary expenses, in connection with the reconstruction, for the experimental use of underground systems of electrical traction, of that part of the London County Council tramways between Westminster Bridge and Tooting : and that the committee be authorised to make all necessary arrangements for the purpose above referred to."

THE Duke of Bedford has been elected by the Council President of the Zoological Society of London, to fill the vacancy caused by the death of the late Sir William Flower.

UPON the recommendation of the Governor-General of India in Council, Her Majesty's Government has conferred upon Surgeon-General Sir J. Fayrer, Bart., K.C.S.I., Indian Medical Service, as a reward for distinguished and meritorious service, a good service pension of 100*l.* per annum.

THE Welby Prize of 50*l.*, offered for an essay on "The causes of the present obscurity and confusion in psychological and philosophical terminology, and the directions in which we may hope for efficient practical remedy," has been gained by Dr. Ferdinand Tönnies, whose essay, translated by Mrs. B. Bosanquet, appears in the current number of *Mind*.

PROF. GUIDO CORA, of Rome, has been elected (by Royal decree) a member of the Upper Council of the Geodetical Works of Italy (Consiglio Superiore dei Lavori Geodetici dello Stato).

THE expedition from the Liverpool School of Tropical Diseases, to which reference has already been made (p. 278), left the Mersey on Saturday in the steamer *Fantee*. Freetown will be the centre of experiments, with special regard to Major Ross's theory as to malaria being propagated by mosquitoes.

THE medical authorities of the Owens College and of the Royal Infirmary, Manchester, have been asked by the Chamber of Commerce to consider the advisability of forming a Manchester committee to co-operate with the Liverpool committee in the establishment and support of the Liverpool School for the study of tropical diseases.

THE annual congress of the British Medical Association was opened at Portsmouth on Tuesday. The president, Dr. Ward Cousins, delivered an address in which he sketched the progress made during the present century in medicine and surgery, with particular reference to recent discoveries in pathology and biology.

THE detailed programme of arrangements for the reunion of the Institution of Electrical Engineers in Switzerland, to be held in Switzerland from September 1 to September 9, has now been issued. The Council have decided that, with the exception of candidates for election, only members (of all classes in the Institution), and ladies and children accompanying them, can be authorised to take part. A number of visits to works and manufactories, and excursions to places of interest, have been arranged, and the programme provides opportunity for members f the Institution to spend a pleasant week in Switzerland.

THE sixth International Agricultural Congress will be held from July 1–8, 1900, in connection with the Paris Universal Exhibition of next year. The work of the congress will be divided into seven sections, as follows: (1) rural economy (agricultural credit, agricultural associations, land surveying, agrarian questions); (2) agricultural education (experimental stations, field experiments, &c.); (3) agricultural science (application of science to agriculture, agricultural improvements); (4) live stock; (5) practical agriculture (industrial crops and agricultural industries); (6) special crops of the South (silk production, early fruits and vegetables, perfume plants and colonial productions); (7) injurious insects and parasites (international measures for the protection of useful animals). Copies of the detailed programme may be obtained on application to the English representative of the International Agricultural Commission, Sir Ernest Clarke, at 13 Hanover Square, London, W.

THE Baly Gold Medal of the Royal College of Physicians of London, instituted in 1866 by Dr. F. D. Dyster, of Tenby, "in memoriam Gulielmi Baly, M.D.," which is awarded every alternate year on the recommendation of the president and council to the person who shall be deemed to have most distinguished himself in the science of physiology, especially during the two years immediately preceding the award, has been awarded to Dr. C. S. Sherrington, F.R.S., Professor of Physiology in University College, Liverpool.—The report of the Laboratories Committee of the College states that, since March 10 last, 1100 doses of antitoxin, each containing 2000 units, and 4425 doses, each containing 4000 units, for the treatment of diphtheria in the hospitals of the Metropolitan Asylums Board have been supplied and all the demands fully met. During this period 19,900,000 units have been supplied. During the same period five doses of 4000 units each have been supplied to the medical officers of health according to instructions received from the Metropolitan Asylums Board. Under the grant from the Goldsmiths' Company 459 doses of antitoxin containing 1,134,000 units have been supplied to the general an children's hospitals in or near London.—Dr. Arthur Foxwell, of Birmingham, will deliver the Bradshaw Lecture of the College on November 2. Dr. P. Horton Smith has been appointed Goulstonian Lecturer, and Dr. W. B. Cheadle Lumleian Lecturer for 1900, and Prof. W. D. Halliburton the Croonian Lecturer for 1901.

THE death is announced of Prof. Balbiani, professor of comparative embryology in the Collège de France.

THE expedition organised by the Peary Club, of New York, for the relief of Lieut. Peary in the Arctic regions started a few days ago. Prof. William Libbey, of Princeton University, is chief of the expedition, and with him are Prof. W. F. McClure, Dr. Arnold E. Ortman, Mr. Charles F. Silvester, and two representatives of the United States Coast Survey. The first object of the expedition is to take provisions and other supplies to Lieut. Peary. After the stores have been unloaded from the *Diana*, the return trip will be converted into a tour for scientific explorations. Chiefly deep sea investigations will be carried on, and specially prepared dredging apparatus have been provided for this purpose. It is expected that the party will return about October 1.

THE Bill having for its object the sanitary regulation of oyster beds has been withdrawn. When the order for the Committee stage of the Bill came before the House of Lords on Monday, Lord Harris said he had to move that the order be discharged. The intention of the Local Government Board in introducing the Bill was to protect as far as possible the public health from attack from diseased oysters; and the Board therefore selected as the local authorities by which the Bill was to be put into operation the councils of counties and boroughs which were concerned with the sanitary matters of their districts. But the Select Committee to whom the Bill was referred after the second reading decided that this was a matter which concerned more the health of the oyster than the health of the human being; and on a division they substituted the Local District Fisheries Committee, which looked after the well-being of fish for the councils of counties which were concerned with the public health as the authority in the Bill. But the Board of Trade, to whom the Bill was referred, decided that the change rendered the Bill impracticable; and in the circumstances the President of the Local Government Board does not intend to proceed further with the measure. The Bill was therefore withdrawn.

AT the meeting of the Institution of Mechanical Engineers held at Plymouth last week, a paper of much historic interest was read by Sir Frederick Bramwell, the subject being the South Devon atmospheric railway, preceded by remarks upon the transmission of energy by a partially rarefied atmosphere. Leaving out of consideration Savery's and such like machines for the raising of water by means of a partial vacuum produced by the condensation of steam, the first suggestion for transmitting energy by the rarefaction of air appears to have been made by Denis Papin in 1695. The matter lay in abeyance for more than a century, and then Mr. G. Medhurst proposed the propulsion of trains within a tube by means of air pressure. In 1824 John Vallance took out his patent, so very well known to all who have interested themselves in this subject of transmission of energy by the pressure of the atmosphere. Excep that Vallance proposed to move his train by the rarefaction of the air, his scheme was a mere repetition of that of Medhurst already mentioned. But the man who really developed this

mode of transmission of energy was John Hague. In addition to using a partial exhaust system to work cranes and tilt hammers, Hague applied this mode of transmitting energy to driving the machinery of powder mills, so as to remove the danger of steam-engine fire to any distance needed for safety. He also applied it to work the individual cutting-out presses and coining presses of a mint which he constructed for Rio Janeiro.

VALLANCE'S (Medhurst's) system of atmospheric railway was put to work in 1861, in the case of the "Pneumatic Postal Despatch," which was, in that year, laid down experimentally in Battersea Fields. In 1863 a line on this system was laid and got to work from Euston to the Holborn Post Office, a distance of about one and half miles, with the intention of going forward another mile to the General Post Office. In this case the ⌂-shaped tube was as much as 4 feet high by 5 feet wide. The trains were "blown" and "sucked" backwards and forwards. A vacuous, or a pressure, condition of a few inches of water was found sufficient for the propulsion. In 1844, Mr. Brunel recommended the atmospheric system for the South Devon Railway, and by 1846 it was actually laid down nearly the whole way from Exeter to Newton. Four atmospheric trains ran on the line each way daily in 1847. In the life of Brunel, it is stated that 865 horse-power were required to do the work that he had a right to expect would have been done by 300 horse-power. By August 1848 the valve had begun to fail throughout its length. The cost had been 1160*l*. per mile, and in August 1848, just four years after Brunel had advised the trial of the atmospheric system, he reported that he did not recommend its extension, and, in fact, suggested it only as an assistant on inclines. The directors then suspended operations, and, afterwards, locomotives were used throughout.

SEVERAL popular articles on scientific subjects appear in the current number of the *Century Magazine*. Of particular interest are two articles on tornadoes, one by Mr. John R. Musick giving a description of a tornado witnessed by him at Kirksville, Missouri, in April of this year, and another by Prof. Cleveland Abbe on tornadoes in general. Mr. Musick's testimony as to the effects of the tornado is most astonishing. He says that when the storm struck the city, "doors, shutters, roofs, and even whole houses were sent soaring and whirling to a height of three or four hundred feet. I saw the wheel of a wagon or carriage and the bodies of two persons flying up into the storm-cloud. One house was lifted upwards to a height of over one hundred feet, when it seemed to explode into a thousand fragments, which went soaring, whirling and mingling with the other débris." Perhaps the most remarkable experiences were those of three persons who were caught up in the storm, and after being carried nearly a quarter of a mile, were let down so gently that none was killed. Several horses and many other animals were taken up by the storm and carried to considerable distances. One horse was carried two miles by the storm and alighted uninjured. An orchard south of the city had the trees torn up by the roots, carried four or five hundred yards, and piled into some vacant fields. An idea as to the fury of the wind may be formed by the size of the trees uprooted. Some of these were from twelve to eighteen inches in diameter, with roots ten feet in length. The earth from which they had been jerked is said to have looked as if it had been torn by dynamite explosions.

As to the origin of tornadoes, Prof. Cleveland Abbe remarks that the point about which there has, perhaps, been the most uncertainty relates to the rotatory motion of the wind at the centre of the path of destruction. From the information he has been able to gather it appears that generally a west or north-west wind is blowing over the country, with a front of many miles in length, which trends south-west and north-east. This cool north-west wind pushes aside a gentler southerly wind that had been prevailing over that same region during the previous twenty-four hours. In the long belt, or trough, where these two winds meet, the warmer southerly wind is suddenly elevated and cooled by expansion, as also by mixture with the under-current of cold north-west wind. A cloud is thus formed, or in fact rolls of clouds, along the whole front of the area of north-west wind. At certain favourable spots the cloud soon becomes so large as to form a special indraft upwards through its centre, and the ascending wind must necessarily acquire a spiral ascending movement. The direction of rotation in this spiral is almost invariably the same as that of the hurricanes of the Atlantic Ocean, or the general storms attending the areas of low pressure that move eastwards over the United States, namely counter-clockwise.

THE Report of the U.S. Weather Bureau for the year ending June 1898 shows that no time has been lost in developing the Meteorological Service of the West Indies; arrangements have been made for observations being cabled twice daily from several islands to Kingston (Jamaica) and the central office in Washington, and negotiations are being carried on with the French authorities for the co-operation of the observers in Martinique. The maintenance of observations at Havana during the period of hostilities with Spain is also very gratifying. The important work of producing a thoroughly satisfactory kite has seriously occupied the attention of the Weather Bureau; sixteen stations have now been completely equipped, and the observers have all received a course of instruction in Washington. The observations hitherto made in the exploration of the upper air by this means contain much information that is new and of practical importance, independently of their value in making weather forecasts. The Canadian Meteorological Service has established a continuous record of the oscillations of the waves of Lake Ontario, which seem to show a connection with atmospheric conditions. These oscilliations are of much interest from several points of view, and the subject is engaging the attention of the U.S. Weather Bureau.

THE second annual report of the Council of the Röntgen Society shows that steady progress is being made. The Society numbers 148 ordinary members and five honorary members. Fresh evidence is continually received of the value of Röntgen rays in surgery, and there is much useful work open to the Society in the way of stimulating improvements in apparatus and in methods of investigation. The Council announce that Mr. William Noble has consented to be nominated as president for the ensuing year. He was among the earliest workers with X-rays, and has done useful service in radiography and on the physical side of the subject which it is the Society's object to advance.

THE volume of *Sitzungsberichte* of the Royal Bohemian Academy for 1898 contains, amongst other communications, a number of mathematical papers. These include notes on theory of curves, by C. Küpper (Prag); on a property of factorials, and remarks on trigonometric series with positive coefficients, by M. Lerch (Freiburg); on the residues of functions defined by differential equations of higher order, and on a system of semi-curvilinear coordinates, by Michel Petrovitch (Belgrade); on the infinitesimal geometry of certain plane curves, by J. Sobotka (Vienna); a note on spherical harmonics, by Franz Rogel (Barmen); and on the principal propositions of stereographic projection regarded as corollaries of Quetelet and Dandelin's theorem, by Carl Pelz (Prague).

FROM Messrs. Williams and Norgate we have received a copy of the *Sitzungsberichte und Abhandlungen* of the "Isis" Society, of Dresden, for 1898. It contains a paper, by W. Hallwachs, on determinations of the refractive indices of solutions.

In it the author gives an account of his differential method with grazing incidence, for which a double-trough refractometer has been used. The process in question has been applied to solutions of brome-cadmium, sugar, di- and tri-chloracetic acid and their potassium salts; and the author investigates the relation between the refractive index and the degree of concentration with a view of determining whether this is influenced to any extent by dissociation. The experiments show that such an influence, if it exists, is too small to be measurable with exactitude. This result is at variance in the case of brome-cadmium with those obtained by Le Blanc and Rohland, but the discrepancy is attributed to an error.

THE twenty-first of the series of electrical papers published by W. G. Hankel in the *Abhandlungen der k. Sächs. Gesellschaft der Wissenschaften* deals with the thermo-electric and piezo-electric properties of certain crystals, including, amongst others, the formates of barium, lead, strontium and calcium, nitrates of barium and lead and sulphate of potassium. It is illustrated by several diagrams showing the distribution of positive and negative electrification over the faces of the several crystals.

THE general results of the magnetic survey of Sicily and the adjoining islands, commenced in 1890 by Prof. Chistoni and Signor L. Palazzo, were recapitulated in a communication by the latter observer to the *Atti dei Lincei*, vi. (2) 11. In *Terrestrial Magnetism* for June 1899, Signor Palazzo now gives a magnetic chart of Sicily showing the course of the isogonal and isoclinal lines, and the isodynamical lines for the horizontal component. The remarkable deviations produced in these curves by volcanic areas are well shown. Signor Palazzo having been appointed as a delegate at the International Magnetic Conference held in connection with the Bristol meeting of the British Association last year, availed himself of the opportunity for instituting a comparison between the magnetic instruments of the Italian Central Meteorological Office and those of Parc Saint-Maur and Kew. The results of this comparison have been published in the *Atti dei Lincei*, viii. (1) 8 and 9, and the author considers that these comparisons fully establish the trustworthiness of the Italian instruments and methods.

FOLLOWING in the footsteps of Japan and France, which countries in 1894 despatched scientific experts to investigate the outbreak of plague in Hong Kong, Germany decided in the year 1897 to send out a commission to study the plague in India, and in February of that year Dr. Gaffky, Dr. Pfeiffer, Dr. Stricker, and Dr. Dieudonné arrived in Bombay. The results of their labours have just been published in a volume of the *Arbeiten aus dem Kaiserlichen Gesundheitsamt*, and covers no less than 356 large quarto pages, whilst copious illustrations, coloured and otherwise, beautifully executed, serve to elucidate the text. The literature of previous outbreaks of plague in India has been carefully summarised by the authors, and the history of the recent severe epidemic has been traced as accurately as possible. As was to be anticipated, a large portion of the report describes the numerous experimental investigations undertaken by the experts, and the results of these researches form a valuable addition to the already bulky records obtained during previous inquiries. Prominence is given to the encouraging results obtained by Haffkine's method of preventive inoculation, and in this connection mention must be made of an official report recently published in India of inoculations against plague made from May to September last year in Hubli. The actual number of inoculations carried out by Surgeon-Captain Leumann and his staff amounted to some 78,000 altogether, and in summarising the results of his extended experience, Captain Leumann remarks that "inoculation arranges itself by the protection it affords in the foremost rank of methods for dealing with this disease."

AN article on "The Ethics of Vivisection," which appears in the current number of the *Edinburgh Review*, ought to be reprinted and widely distributed as a plain and dignified statement of fact as to the purpose of physiological research and the actual conditions under which it is carried on. So many misleading leaflets and tracts have been published by opponents of experimental work in physiology that all persons desirous of arriving at the truth of the matter should give consideration to the side or the case presented in the article to which reference has been made. In the course of the article the pain deliberately inflicte upon animals for mercenary motives, for sport, for food, for ornament, and other purposes is mentioned, and the very apt remark is made that "the only form of vivisection to which he [an opponent of vivisection] objects is that which furnishes not luxury, amusement, or vanity, but knowledge." But this only meets objections with a *Tu quoque*, and a specific statement of what civilised man owes to experimental physiology is more convincing to the logical mind. Such a statement is given in the article.

REFERRING to the results of the application of the experimental method advocated by Bacon and Harvey, the writer in the *Edinburgh Review* points out that physiologists and biologists "have enriched practical surgery with antiseptic methods and with anæsthesia; with control over hæmorrhage while operating; with a rational and successful treatment of aneurism and of glaucoma; with the power in not a few cases of removing a tumour even from the brain itself. In medicine proper, all that is summed up in the phrase 'heart disease,' all knowledge of arterial tension and its influence on the whole organism, have all been evolved gradually from the basis of Harvey's discovery. All our knowledge of nervous disease is based upon vivisectional experiments, from Charles Bell to Hitzig and Ferrier. Almost all our knowledge of the digestive processes, of angina pectoris and of methods of relieving it, has been gained through experiment. Practical medicine has been enriched through experimental research with such drugs as digitalis, cocaine, croton-chloral, nitrite of amyl; with the method of auscultation; with a knowledge of the cause of tuberculosis, typhoid fever, cholera; with the life-history of parasites; with the cause of myxœdema and related conditions and how to relieve them, and with a life-saving remedy for diphtheria. . . . It is, in fact, no figure of speech, but the simplest of truths, to say that everything of solid value in medicine and surgery is based upon knowledge gained by the experimental method." With this quotation we leave the article, convinced that it will be of much assistance in the spread of truth and the advancement of science.

A SHORT article, illustrated by reproductions from photographs, on the Medanos, or moving sand-hills of the Peruvian desert, is contributed to *Pearson's Magazine* by Mr. George Griffith.

THE following official botanical publications have reached us from the United States:—Sugar as food, by Mary H. Abel (U.S. Department of Agriculture, *Farmers' Bulletin*, No. 93); Mushrooms, II., by Prof. G. F. Atkinson (Cornell Univ. Agricultural Experiment Station, *Bulletin* No. 108); Notes from the South Haven sub-station; Vegetable tests for 1898; Bush fruits for 1898; Combating disease-producing germs; Killing the tubercle bacillus in milk (Michigan State Agricultural College Experiment Station (*Bulletins* Nos. 169–173).

THE *Journal of Applied Microscopy* continues, in the numbers most recently received (May–July), its useful *résumé* of recent work on microscopical technique:—Methods of plant histology,

by Prof. C. J. Chamberlain; Current bacteriological literature, by Prof. H. H. Waite; Normal and pathological histology, by Dr. R. M. Pearce; Neurological literature, by Edith M. Brace. Among original communications in the same branch of science we may mention an improvement in the technique of making blood-serum culture media, by Ernest C. Levy; and preparing sections of cochlea for microscopical examination, by M. T. Cook and H. H. Zimmermann.

TWO new volumes have been added to the series of brochures published by MM. Georges Carré and C. Naud under the general title of "Scientia." The volumes are: "Les actions moléculaires dans l'organisme," by Prof. H. Bordier, and "La coagulation du sang," by Prof. Maurice Arthus. Each book comprises about one hundred pages, and shows the present state of knowledge of the subject dealt with in it.

THE seventh volume of the renowned "System of Medicine," edited by Prof. Clifford Allbutt, F.R.S., has been published by Messrs. Macmillan and Co., Ltd. The volume continues the treatment of the subject of diseases of the nervous system. In the eighth volume, which will conclude the work, this subject will be completed, and the full sections on mental diseases and diseases of the skin will be added. When the final volume has appeared, it will be reviewed with others not yet noticed in these columns.

THE additions to the Zoological Society's Gardens during the past week include a Purple-faced Monkey (*Semnopithecus cephalopterus*, ♂) from Ceylon, presented by Mrs. Usborne; a Common Badger (*Meles taxus*, ♀), British, presented by Mrs. F. Travers; a Zebu (*Bos indicus*, ♂) from India, presented by Mr. Smith Rylands; two Common Squirrels (*Sciurus vulgaris*), European, presented by Miss E. B. Sparrow; a Martinique Gallinule (*Ionornis martinicus*), captured at sea, presented by Mr. H. A. Pare; a Raven (*Corvus corax*), European, presented Mr. P. Stuart; two Tengmalms Owls (*Nycla tengmalmi*) from Norway, presented by Mr. P. Musters; an Adorned Terrapin (*Chrysemys ornata*) from Central America, presented by Mrs. R. J. Aston; a Common Snake (*Tropidonotus natrix*) from Italy, presented by Mr. T. G. Gunn; a Common Badger (*Meles taxus*) from Siberia, a Common Hamster (*Cricetus frumentarius*, European, a Ring-necked Pheasant (*Phasianus torquatus*) from Mongolia, four Horsfield's Tortoises (*Testudo horsfieldi*) from Central Asia, two Blackish Sternotheres (*Sternothaerus nigricans*) from Madagascar, a Japanese Terrapin (*Clemmys japonica*) from Japan, six Land Lizards (*Lacerta agilis*) from Central Europe, six Crested Anolis (*Anolis cristatellus*) from the West Indies, two Long-snouted Snakes (*Dryophis mycterians*) from India, a Common Snake (*Tropidonotus natrix*), two Common Vipers (*Vipera berus*), British, a Glass Snake (*Ophiosaurus apus*) from Southern Europe, deposited; two Common Wolves (*Canis lupus*, ♂ ♀) from Siberia, two Yellow-tufted Honey-eaters (*Ptilotis auricomis*) from New South Wales, two Nonpareils (*Cyanospiza ciris*, ♂ ♀) from North America, purchased.

OUR ASTRONOMICAL COLUMN.

TEMPEL'S COMET 1899 *c* (1873 II.).—

Ephemeris for 12*h. Paris Mean Time.*

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br.
Aug. 3	20 56 14·6	−25 43 7	
4	57 26·2	26 14 6	3·587
5	58 37·9	26 44 34	
6	20 59 49·8	27 14 29	
7	21 1 1·9	27 43 48	
8	2 14·3	28 12 29	3·447
9	3 26·9	28 40 30	
10	21 4 39·8	−29 7 48	

MARS DURING OPPOSITION 1898–1899.—MM. Flammarion and Antoniadi contribute to *Astr. Nach.* (Bd. 150, No. 3581) the results of their observations of Mars during the last opposition of the planet. The work was done at the Observatory of Juvisy, with an objective by Mailhat of 0·26m. aperture and 3·81m. focal length. The magnifying powers employed were 145, 224, 308, 411, and 607, the best images being obtained with the power of 308. Tables are given showing the progressive diminution in the extent of the polar caps, and of the whitening of the land surface under varying degrees of obliquity of the sun's rays. Two plates accompany the paper, showing the whole of the details observed, and in the description of these several differences are noted in comparison with the data given by Lowell.

As indicating the probable transparency of the Martian atmosphere, mention is made of the visibility of the Mare Tyrrhenum as a black marking quite up to the edge of the disc. The number of canals seen at Juvisy has been thirty-six, the majority of which were large and diffuse. Those easiest seen were Boréosyrtes, Cerberus and Styx. Several observations of gemination were made, which it is thought will throw some light on the cause of the phenomenon.

PHOTOGRAPHY OF NEBULÆ AND STAR CLUSTERS.—At the meeting of May 3 of the Astronomical Society of France, M. L. Rabourdin, in the course of a paper on the history of the subject, showed some remarkably fine photographs of nebulæ and star clusters, and he gives a description of them, and of how they were obtained, in the July number of the Society's *Bulletin* (*Bull. Soc. Ast. Fr.*, July, pp. 289–299). The instrument was the large reflector of the observatory at Meudon, which was kindly placed at M. Rabourdin's disposal by M. Janssen. It has an aperture of one metre and a focal length of three metres, and is thus admirably fitted for the photography of faint objects of extended area. In the same number (pp. 299–304), M. Janssen furnishes some remarks on the above paper, entering fully into the question of astronomical photography, in the course of which he suggests obtaining a photometric scale for the measurement of the brightness of nebulæ by putting standard stars slightly out of focus, thus obtaining small circular discs on the plate instead of points, and then measuring the opacity of these circles.

EXPERIMENTAL INVESTIGATIONS ON TELEGONY.[1]

I. *Introductory.*

THE belief in telegony, or what used to be known as the "infection of the germ" or "throwing back" to a previous sire, has long prevailed. It may for all we know be as old as the belief in "mental impressions," which has had its adherents since at least the time of the patriarchs. During the eighteenth century the "infection" doctrine was frequently discussed by physiologists, and since Lord Morton, in 1820, addressed a letter to the Royal Society on the subject, believers in "infection" have been increasing all over the world, with the result that one seldom now hears of breeders or fanciers who are not influenced by the doctrine, while physicians and others interested in the problems of heredity either as a rule take telegony for granted or see nothing improbable in the "infection" hypothesis.

It must, however, be admitted that, notwithstanding the criticisms of Weismann and others, very different views are entertained by the believers in telegony, not only as to the cause, but as to the results, of "infection." By some telegony is confounded with simple reversion or atavism, while the better informed generally assume that "infection" invariably results in the subsequent offspring repeating more or less accurately the characters of the first or of a previous sire. In a breeders' journal of some standing there appeared recently under the heading "Colour of Animals" the following sentence:—"Greys show in breeding a great tenacity of assertion, as they are few in comparison to other colours in the Stud Book, but they reappear and no doubt go back to the Arab, and prove telegony to be a fact" (*Live Stock Journal*, May 12, 1899, p. 588). This shows simple reversion is sometimes mistaken for telegony. In support of the view that "infec-

[1] "Experimental Contributions to the Theory of Heredity. A. Telegony." By Prof. J. C. Ewart, F.R.S., University of Edinburgh. (A paper read before the Royal Society, June 1.)

tion" is commonly supposed to lead to "throwing back" to a previous sire many instances could be given, but the following from an article on telegony by De Varigny will suffice. De Varigny states that an ordinary cat which had kittens to a tailless Manx cat subsequently produced several tailless kittens to a normal cat of her own breed (*Journal des Débats*, September 9, 1897).

An extended series of experiments with various kinds of animals has led me to the conclusion that if there is such a thing as telegony it is more likely to result in the subsequent offspring "throwing back" to an ancestor of the "infected" dam than to a previous mate. This view of telegony (which has not been insisted on hitherto) will be made at once evident by an example. A sable collie crossed with a Dalmatian produced three pups which in their coloration are extremely like young foxhounds; instead of numerous small spots each has a few large blotches. According to the common view of telegony this collie, if infected, should next produce with a dog of her own breed one or more Dalmatian-like pups. If, however, the offspring of a collie and a Dalmatian are like foxhounds the subsequent offspring to a collie of the same colour and strain could hardly be expected to present Dalmatian characters, *i.e.* show numerous small spots. But if "infection" as a rule results in the subsequent offspring "throwing back" either to the ancestors of the sire or the dam, it will be extremely difficult, if not in many cases impossible, to distinguish telegony from simple reversion.[1]

But though "infection," if it does take place, is likely, as a rule, to lead the subsequent offspring to resemble the ancestors of the dam, it may in certain cases possibly lead to their "throwing back" to a previous sire. This result might follow if the previous sire happened to be highly prepotent. For example, Highland heifers often produce to a Galloway bull hornless black offspring indistinguishable from pure Galloways. If infected by the Galloway bull, these heifers might afterwards produce Galloway-like calves when mated with long-horned bright coloured bulls of their own breed.

It is now commonly believed that if there is such a thing as telegony it results from the unused germ cells of the first (or previous) sire infecting—blending with—the unripe germ cells in the ovaries of the dam. Were this possible, the subsequent progeny would in all probability in a mild way resemble the previous sire, but if this is impossible then infection—due perhaps to some obscure change in the constitution or reproductive system of the dam—is more likely to lead to more or less marked reversion to the ancestors of the dam. All my observations point to its being impossible in the Equidæ for the unused male germ cells of the first sire to infect the unripe ova. The spermatozoa lodged in the upper dilated part of the oviduct of the mare are dead, and in process of disintegrating, eight days after insemination; they probably lose their fertilising power in four or five days. There is no reason for supposing that in the Equidæ they survive longer in or around the ovary. Further, though at the time of fertilisation there may be several large Graafian follicles in each ovary containing maturing ova, all these follicles disappear long before the period of gestation is completed. The subsequent foals are developed from successive new crops of ova into the composition of which it is inconceivable any of the spermatozoa of the first sire could by any chance enter. A study of the ovaries hence tends to confirm the view that "infection" (if there is such a thing) is as likely to cause reversion to a former ancestor of the dam as a "throwing back" to a previous sire.

Having made these general observations, it will be well next to consider critically the case of "infection" communicated in the letter to the President of the Royal Society in 1820[2] by the Earl of Morton. Though many other instances of supposed "infection" have been recorded, Lord Morton's mare may be said to still hold the field—the theory of telegony still mainly rests on the assumption that this historic mare was "infected" by a quagga some years before she passed into the hands of Sir Gore Ouseley and produced three "colts" to a black Arabian horse. One might even go further and without much exaggeration assert that the telegony hypothesis at the present moment mainly rests on an allegation by Sir Gore Ouseley's stud groom.

It has been generally assumed that Lord Morton's mare (a nearly purely bred chestnut Arab) was "infected" for two reasons (1) because the subsequent offspring were of a yellowish-brown colour and more or less striped, and (2) because, according to Sir Gore Ouseley's stud groom, the mane of one of the striped foals had always been upright, while in another it arched to one side clear of the neck. The presence of stripes in the subsequent offspring has never been questioned, nor yet is there any doubt that when Lord Morton in 1820 inspected the "colts" the mane in the filly was upright as in the quagga, while that of the colt resembled the mane of Lord Morton's quagga hybrid. There is, however, an absence of trustworthy evidence that the filly's mane had *always* been upright as alleged to Lord Morton by Sir Gore Ouseley's stud groom.

Were the evidence in support of this allegation satisfactory, there would I think be no escape from the conclusion that Lord Morton's mare was "infected" by the quagga. Hitherto the presence of stripes on the "colts" has generally been looked upon as affording strong evidence of "infection." Believers in telegony admit that stripes are not uncommon in Norwegian and certain other breeds of horses, but, with Mr. Darwin, they have taken for granted that they never or very rarely occur in Arabs.

I find, however, that though in Arabia dun-coloured horses are disliked and never used for breeding, stripes even in the most renowned strains are not so uncommon as is generally supposed. I have now a purely bred Arab filly of about the same colour as Lord Morton's filly, but, unlike the filly we have heard so much of, both the fore and hind legs are marked with distinct dark bars, and there are faint indications of stripes across the withers and a distinct dorsal band. The history of this filly (bred by Mr. Wilfred Scawen Blunt at Crabbet Park, Sussex, and very kindly presented to me) is well known for many generations; none of her ancestors could possibly have been "infected" by a zebra. The dun colour and stripes are doubtless the result of simple spontaneous reversion, for, unlike Lord Morton's mare, there is no history of a cross in her pedigree. This filly proves that even in high-caste Arabs of the best desert blood a dun colour and stripes may unexpectedly appear.

As to the occurrence of stripes in other breeds I could give, were it necessary, many instances. A year ago I had in my possession a light bay (or yellow dun) pony, which showed nearly as many stripes on the trunk as the Gore-Ouseley filly, and in addition had several interrupted narrow stripes on the forehead.[1] Moreover, the stripes on the Gore-Ouseley "colts," while agreeing with stripes occasionally seen in horses, differ in their arrangement from the stripes in the quagga. The stripes themselves are evidence of reversion, but nothing more; and seeing that pure bred horses sometimes show quite as many stripes, we are not justified in assuming that but for the dam of the "colts" having been first mated with a quagga the stripes would not have appeared.

Hence unless it is proved that the mane in the filly and colt were naturally erect, or nearly erect, the case for the "infection" of Lord Morton's mare will be lost. It may be well to quote the passage from Lord Morton's letter referring to the mane. It is as follows:—"That of the filly is short, stiff, and upright, and Sir Gore Ouseley's stud groom alleged it never was otherwise. That of the colt is long, but so stiff as to arch upwards and to hang clear of the neck, in which circumstance it resembles that of the hybrid. This is the more remarkable as the manes of the Arabian breed hang lank and closer to the neck than that of most others" (*Phil. Trans.* 1821).

I am not prepared to accept the allegation as to the manes for the following reasons:—

(1) I have had twelve zebra hybrids under observation, and in each case the mane, though erect to start with, always after a time arched over to one or both sides. The stud groom's statement, it seems to me, proves too much. If in the quagga hybrid and in all my horse hybrids the mane, sooner or later, falls to one side it is a little remarkable that in the pure bred two-year-old filly it had been always upright.

I may here mention that the hair of the mane of zebra hybrids is shed annually; it is for this reason that the mane in hybrids is never long enough to hang close to the neck.

(2) The mane in the drawing of the filly by Agassé is no

[1] That reversion ever occurs has been questioned by Bateson ("Materials for the Study of Variation") and others, but I have already (NATURE, February 9, 1899) proved beyond doubt that reversion can be easily induced by intercrossing distinct types, and I have recently heard of several instances of spontaneous reversion—reversion not induced by intercrossing.

[2] *Phil. Trans.*, 1821.

[1] See Fig. 36, "The Penycuik Experiments," A. and C. Black, 1899.

represented as upright, but as lying to one side. If the mane had remained erect during the first two years, by virtue of shedding its hairs, it could not very well have lost this habit and fallen completely over to one side subsequently, say, during the fourth year. From the mane being erect in 1820, and hanging to one side in 1821 or 1822, when Agassé's drawing was made, the presumption is that the mane of the "colts" had been cut some time before they were examined by Lord Morton.

Two years ago I had a bay Arab with a mane which was to start with short, stiff and upright; some months later it arched freely to one side, as in my zebra hybrids, and later still it hung lank and close to the neck.

(3) There is always an intimate relation in the Equidæ between the mane and the tail; when the mane is short and erect the upper third or so of the tail is only covered with short hairs, which, like the hairs of the mane, are annually shed. Lord Morton noticed nothing peculiar about the tail of the "colts," and the tail of both the colt and filly in Agassé's drawings is the tail of a high-caste Arab. This seems to me to warrant the conclusion that the filly's mane had been hogged some time before Lord Morton's visit.

It thus appears that the evidence in support of the belief that Lord Morton's mare was "infected" by the quagga is at the best far from satisfactory. The same may be said of the evidence in support of all the other supposed cases of telegony in the Equidæ—of, amongst others, Lord Mostyn's mare, referred to by Darwin ("Animals and Plants," vol. i. p. 435, 1875); of the mule-like mare in the Paris Gardens, referred to by Tegetmeier and Sutherland ("Horses, Asses and Zebras," p. 81); and of the African ass (*Equus asinus*), still in the Zoological Gardens (London), which now and then has a reddish-coloured foal, like the cross-bred foal she produced in 1883 to an Asiatic ass (*E. hemionus*).

Although I am now satisfied that Lord Morton's case throws little light on the telegony hypothesis, like many others I had no very decided views on the subject some years ago, and hence when arranging in 1894 to make a collection of horse embryos, I decided to repeat, as far as circumstances permitted, what is commonly called Lord Morton's experiment. For this purpose I procured early in 1895 three zebras and a number of mares. Two of the zebras died during the winter of 1895, but the third—a handsome stallion of the Chapman variety (*E. burchelli* v. *chapmani*)—still survives and is now thoroughly acclimatised.

During 1895 I only succeeded in mating the zebra with one mare, and hence there was only one hybrid born in 1896. During the last two years, however, quite a number of hybrids have made their appearance, and the dams of several of the hybrids have subsequently produced pure-bred foals. The time has hence come when some of the results of the experiments may with propriety be communicated to the Royal Society.

"II. *Experiments with West Highland Ponies.*" By *Lord Arthur Cecil, Orchardmains, Kent, and J. C. Ewart.*

The first mare mated with the zebra was a black West Highland pony (Mulatto), set apart for the telegony experiments by Lord Arthur Cecil. The better bred West Highland ponies are supposed to have descended from "Armada" horses, and are hence perhaps related to Mexican and Argentine horses, so often dun-coloured and partially striped. Mulatto's hybrid (Romulus, born August 12, 1896) is, on the whole, more a zebra than a pony both mentally and physically. He is especially remarkable in being more profusely striped than his sire (the zebra Matopo) in having a heavy semi-erect mane, which is shed annually, and in having a mule-like tail from the upper third of which the longer hairs are periodically shed. The body colour of the hybrid varies from a dark orange colour to a mouse-dun; the stripes, of a reddish-brown colour, on the head are dark brown or nearly black on the trunk and limbs.

In the number and plan of the stripes, the hybrid agrees more closely with the Somali zebra than with any of the Burchell zebras. Over the brow, *e.g.* there are narrow rounded arches instead of somewhat broad pointed arches as in his sire, the neck and trunk have quite double the number of stripes found in the sire, while over the croup in the position of the "gridiron" of the mountain zebra there were at birth irregular rows of spots, which in course of time blended to form somewhat zig-zag, narrow, transverse bands. The ears are nearly as large as in the sire, while the eyelashes are longer and distinctly curved. In his movements the hybrid resembles his sire, and like his sire he is always on the alert, very active and suspicious of unfamiliar objects. Further, in his call he agrees far more with his sire than his dam. In being profusely striped, Romulus differs greatly from the quagga hybrid bred by Lord Morton, in which the stripes were fewer in number than in many dun-coloured horses.

Mulatto's second foal arrived in July 1897, the sire, Benazrek, being a high-caste grey Arab horse. Like Lord Morton's colts, Mulatto's foal by the Arab horse, in make, action and temperament, agreed with ordinary foals, but it differed from the majority of foals in presenting quite a number of *indistinct* stripes—subtle markings only visible in certain lights. These stripes differed but little from the body colour, which varied from dark bay to brown. Though few references have been made to the occurrence of stripes in foals, they are, we find, far from uncommon. As is well known, Mr. Darwin once bred a striped foal by putting a cross-bred bay mare to a thoroughbred horse. This foal was for a time marked nearly all over with obscure dark narrow stripes, plainest on the forehead, but also distinct over the croup ("Animals and Plants," vol. i. p. 60).

There is no figure of Mr. Darwin's striped foal, but from the description given there can be little doubt that the markings were more abundant than in Mulatto's second foal. In this foal (as in Mr. Darwin's) the stripes became more and more indistinct, and by November they had almost vanished. Unfortunately the foal died when about five months old, and hence it is impossible to say whether any of the stripes would have persisted. It will be evident that Mulatto's second foal helped but little to clear up the vexed "infection" problem. Mulatto missed having a foal in 1898, but she recently produced at Knole, Kent, her third foal. The sire (Loch Corrie) of this foal belongs to the Island of Rum section of the West Highland ponies, and closely resembles Mulatto. The third foal has about as many stripes as the second. As in the second, they are most distinct over the croup and hind-quarters; and as in the second, they differ both from the markings in the previous sire, the zebra, and from the markings on the hybrid Romulus.

This third foal, which was born on May 6, 1899, seemed, like the second, to lend some support to the "infection" hypothesis. Fortunately, since it made its appearance, two other West Highland mares have had foals to Loch Corrie. These foals put all doubt as to the nature and significance of the stripes on Mulatto's second and third foals at an end.

One of the dams is of a brown colour, the other is nearly black. Though neither the brown dam nor the black has ever seen a zebra, both foals are marked in very much the same way as Mulatto's, and some of the stripes in one of the new foals look more like persisting than the stripes on Mulatto's third foal. Hence, in order to account for the markings on Mulatto's foal to the grey Arab, and on her foal to the black West Highland pony, it is unnecessary to fall back on the "infection" hypothesis.

"III. *Experiments with Shetland, Iceland, Irish, Thoroughbred and other Ponies.*" By *J. C. Ewart.*

An effort was made to cross four Shetland ponies with the zebra stallion, but I only succeeded in obtaining one hybrid. The dam (Nora) of this hybrid closely resembles, except in size, the Island of Rum ponies—she is a small edition of Mulatto. Her first foal, by a black Shetland pony, was of a dun colour, and nearly as striped as Sir Gore Ouseley's filly; her second is the most zebra-like of all my hybrids; her third closely resembles her sire, a bay Welsh pony. For some time after birth there were faint indications of stripes over the hind-quarters of this foal, but now it is a year old there are no markings or any other suggestions of a zebra. It is not a little suggestive that the foal bred from this pony before she was mated with the zebra was distinctly striped, while the subsequent pure bred foal has no stripes.

Of five Iceland ponies put to the zebra only one produced a hybrid. This hybrid was faintly striped, and showed less of the zebra than any of the others. The dam, a prepotent yellow and white (skewbald) pony, had first of all a light bay foal to an Iceland pony. Her third foal, by a bay Shetland stallion, is a skewbald, and in the size and arrangement of the brown patches closely resembles the dam. There is no hint whatever that the Iceland pony has been "infected" by the zebra.

Several Irish mares were put to the zebra, and two of them (bays) have first produced hybrids and subsequently pure bred foals. A cream-coloured Irish-Canadian mare unfortunately died before her hybrid foal was born. One of the bay mares

had a bay hybrid richly striped; the other a hybrid with but indistinct stripes. The subsequent foals—one by a chestnut thoroughbred horse (Tupgill), the other by a hackney pony (Mars Royal)—are bays, not only devoid of stripes, but affording no indication whatever that their dams had been previously mated with a zebra.

Although I experimented with seven English thoroughbred mares and an Arab mare, I only succeeded with one—a small chestnut. This mare produced twin hybrids last summer; she has this summer a foal to a thoroughbred chestnut horse (Lockstitch). One of the twins died soon after birth, the other, richly but unobtrusively striped, in its colour and make strongly suggests his dam. The chestnut mare's new foal neither in make, colour nor action in any way resembles a young zebra nor a zebra hybrid. In 1897 a bay mare by a bay Arab horse (Hadeed) was for some months in foal to the zebra. Since she miscarried in 1896 she has had two foals to a thoroughbred horse (Lockstitch). Neither of these foals in any way suggests a zebra. In this case the unused germ cells of the zebra had presumably a better chance of reaching the ovum from which the first of the two pure-bred foals was developed than is usually the case.

Attempts were made to cross Welsh, Exmoor, New Forest, Norwegian and Highland ponies with the zebra without success, and though a cross-bred Clydesdale has twice had a hybrid, she has not yet produced a pure-bred foal. The experiments, as far as they have gone, afford no evidence in support of the telegony hypothesis.

INVESTIGATIONS ON MOSQUITOES AND MALARIA.[1]

I HAVE the honour to report the results of my observations since my arrival here on December 21, 1898.

Major Ross, I.M.S., first demonstrated and explained to me his method of dissection of the mosquito and the structures normally met with. From prepared specimens he then showed me the bodies met with after feeding these mosquitoes on birds infected with the proteosoma and the change day by day which they showed, ending with a demonstration of the germinal threads in cysts in the stomach wall, as seen in the fluids of the body and in cells in the salivary gland.

On my arrival there were in the laboratory, in test-tubes, series of mosquitoes fed on birds infected with proteosoma on the night of November 30, December 10, December 12, December 15, and December 20.

Of each of these series Major Ross dissected specimens for me after killing the mosquitoes with chloroform, and again demonstrated in these the same bodies that he had already shown me in prepared specimens; pointing out and demonstrating as he went on that in the older mosquitoes it was possible on cutting the thorax to observe the nature of the contents both of the coccidia in the stomach and of those of the cells of the salivary glands.

The points showed to me I readily observed.

From series of mosquitoes before mentioned I day by day examined both those which died and others I killed, and was as readily able myself to repeat the observations and in the earlier series to trace the changes in the size and nature of contents of the coccidia.

I also examined a large number of mosquitoes caught about the laboratory, and others which had been raised from larvæ. In no case did I find either coccidia in the stomach wall, germinal threads in the body fluids, or in the cells in the salivary gland; nor did I find "black spores" in them.

Major Ross informed me that his published results were based on observations made in the hot season when the temperature was 80° F., or more; and that now I should find the changes considerably slower, as it was the cool season, but that the sequence of events was the same.

My observations on the mosquitoes fed on December 20 and December 15 showed that this was the case, and that the coccidia advanced more slowly than the published results indicated. He also informed me that mosquitoes fed less readily and more difficulty was met with in rearing them to a spore-bearing age.

[1] Dr. Daniels's Report to the Secretary of the Malaria Investigation Committee of the Royal Society, London, on the results of observations made by him in Calcutta in conjunction with Major Ross, I.M.S. Dated Calcutta, January 23.

These difficulties the use of the incubator was only partially successful in obviating.

On the evening of January 1, following exactly in Major Ross's lines, I commenced a repetition of his main experiment. Two mosquito nets, free from rents, were taken, and in them were released a large number of grey mosquitoes reared from larvæ.

In the one, four birds were placed; in three of them on December 31 I had found proteosoma in large numbers, and in the fourth a moderate number.

In the other net two birds, in whose blood no proteosoma had been found, were placed; these two died two and three weeks later, and no pigment was found in their organs, and repeated examinations of their blood had failed to show proteosoma.

On January 2 none of the mosquitoes had fed, and on January 3 only two in the first net and eight in the second. On January 4, a warm night with a minimum temperature of 59·2° F., sixty-three mosquitoes were found gorged with blood in the morning, and were caught in separate test-tubes plugged with wool and placed in the incubator. Eighteen in the other net, where the non-infected birds were placed, the control series, were similarly collected; these were caught in the same manner and treated in the same way.

On the following two evenings, with minimum temperatures of 60·7° and 63·2°, sixty-eight and forty-six mosquitoes were fed on the infected birds and were kept for the preparation of specimens. Twelve mosquitoes were fed on the non-infected birds, and were used as additional controls so as to bring the number of the control on Blue Jay with numerous Halteridia.

On the third day the sixty-three, with the exception of those killed for examination or dead, were released inside a clean net free from mosquitoes, and birds free from proteosoma were also placed in it.

In the morning all mosquitoes found inside were collected, and most of them had fed well; the minimum temperature was 63·2° F.

This is the method Ross employs to re-feed the mosquitoes. If infected birds are used, you get a younger generation of coccidia; so I used sterile birds. The method works fairly well in warm weather; but there is always some loss, as the full number are not collected again in the morning. As the process is repeated over and over again, this loss becomes serious, the more so the longer the period required for maturation. In a frequently repeated process of this kind there is always the possibility of an outside mosquito getting in.

The mosquitoes were not fed on the following night, as they were full of blood; but most of them voided it during the night, and many died next day.

The remainder were given the opportunity of re-feeding every night after this; but a spell of cold weather ensued with minimum temperatures of 44° F.–49° F.; only on one night did it exceed 50° F., and on these nights few fed well or at all, and there was a consequent continued heavy mortality, only one being alive on the tenth day, and that subsequently escaped in the night.

This method of feeding is very unsatisfactory in exceptional weather of this kind; the mosquitoes in the day are kept warm in the incubator, and rapidly digest their food, whilst at night the cold renders them torpid and they do not feed.

The control mosquitoes were treated in exactly the same manner and fed on birds free from proteosoma. The last died on the thirteenth day.

The results of the two series are as follows:—

Sixty-three fed on proteosomal birds.
Forty-nine examined, three reserved for sections, one too much decomposed for satisfactory examination.
Ten not accounted for, lost in the nets.

Of the forty-nine examined, two were killed on the first day—that is, under twenty-four hours, and possibly under twelve hours, after they had fed. No coccidia were found in these. Two more were examined the following morning, under thirty-six and possibly under twenty-four hours after they had fed; no coccidia were found in these.

In two examined about 4 p.m., the minute pigmented coccidia were found; that is, under forty-six and possibly not more than thirty-four hours after they had fed on the infected birds.

The remainder were examined on the following days, the largest numbers, eighteen, on the fourth day and twelve on the seventh day, as on these two days those numbers died.

In every mosquito examined, with one exception, the coccidia were found usually in numbers, but in one there was only one coccidia.

The exception occurred on the ninth day; as by then they had been re-fed several times, it may have been an outside one which had effected an entrance.

So that out of forty-five mosquitoes fed on the infected birds and examined more than thirty-four hours after, forty-four contained coccidia.

This I may say is a more successful result than in the other series I have seen.

The other two sets of mosquitoes were used by all of us for preparation of specimens, and no record was kept of the number of failures. From my own examination only about three-fourths of them developed coccidia.

The treatment was a little different, and half of them were not incubated for several days.

Of the controls fed on birds free from proteosoma, thirty-eight in number and treated in the same manner, twenty-nine were examined and nine are unaccounted for—"lost in the nets." None of the twenty-nine were examined on the first day, but one was in the afternoon of the second day. The largest number examined were on what would correspond to the fourth and seventh days, *i.e.* seven and five; but there were four each on the fifth and sixth days.

It will be observed that these control mosquitoes were not, as the other series, collected on one, but on three nights. A very slight difference in breeze and light seems to affect the number who bite; or any extra restlessness on the part of the birds would have the same result.

In none of these twenty-nine were coccidia found. Of the eighteen fed on the Blue Jay with Halteridia, twelve were examined from two to six days after feeding and none contained coccidia.

The forms found on the second day measured 6–7 μ, some of them a little more. They were oval bodies containing scattered granules of black pigment, and had a sharp, clear outline.

I incised the stomach, and by repeated washing and compression with a cover-glass was able, not only to wash out the contents of the stomach, but even to express the loosely attached epithelium, so as to leave the stomach as a transparent clear bag. To this outer wall the majority of coccidia remained fixed, though in one of the mosquitoes I observed some to escape with the epithelium. At no subsequent date could I ever detach any by this process, though some coccidia would be ruptured.

The next morning the smallest measured 10 μ; some were 12 μ. On the sixth day they were met with up to 30 μ; by this time the pigment had absolutely as well as relatively diminished.

In another three days some of them reached 60 μ; and in the last of the series examined (tenth day) there were coccidia measuring 70 μ.

The coccidia could now be seen to project from the outer wall of the stomach; very few contained pigment, and that in small amount.

Some of the coccidia were clear and others had a granular appearance, but in none were there either black spores or germinal threads to be seen.

For the further development the early deaths of the mosquitoes from the inclemency of the weather rendered this series useless.

One of those which were infected on the night of January 5, and another infected on January 7, did reach this stage; and in the last of those first fed on January 5, which died on January 22, ruptured cysts were found by me in the stomach wall, as well as numerous cysts containing mature germinal threads, and these threads were also found in the body fluids and in cells in the salivary glands.

My observations are, therefore, mainly based on those infected November 30 and subsequent dates before my arrival, and on some infected December 22. The one infected on January 5 died on January 19, and the coccidia in it had an appearance of striation.

On adding salt solution (gr. xv. to the ounce) and pressing on the cover-glass, a projecting coccidium was ruptured; and the contents poured into the fluid, leaving the cyst wall still attached to the stomach.

The contents were seen to consist of a mass of shrivelled threads. This appearance in the other series mentioned I have frequently seen.

These threads, Ross's germinal threads, are sickle-shaped bodies about 14·15 μ in length, they stain with logwood or methyl blue, but not strongly; on adding water or Farrant's solution they lose their shrivelled appearance and become more rounded. Nearer one end than the other is an unstained portion (? nucleus).

They show no signs of movement; but as they are invisible in water and only become visible when shrivelled by the salt or stained, it may be doubted if they have been seen alive.

If a mosquito has its thorax incised when rather older than this, similar threads are found in the fluid exuded if salt solution is added to it.

In such a case ruptured cysts are found in the stomach wall.

The position as regards the salivary gland involves a difficulty which is not met with in any other part of the examination.

The dissection of the stomach is easy; that of the salivary gland in its entirety is not, and for some reason appears to be more difficult in the old infected mosquitoes. Any rough manipulation results in the detachment of the cells, and little more than the duct is left. In most cases, however, one entire gland, or portions of both, can be exposed in fair condition even in old infected mosquitoes.

In every case where this was done and germinal threads were found in the body-fluids, the germinal threads were also found in some of the cells in the salivary gland, and no similar threads have I found in a large number of salivary glands examined by me in mosquitoes bred from larvæ, free about the laboratory, or in the earlier stages of coccidial infection.

The affected cells can be distinguished with a low power, as they have a granular appearance, whilst the unaffected cells are quite clear.

With a high power, if not very numerous, the isolated germinal threads can be clearly distinguished and recognised by their peculiar shape and shrivelled appearance (the examination must be made in salt solution). If numerous, the individual threads can be no more distinguished than in the coccidia, but, as in those, pressure on the cover-glass will rupture the cell, and the germinal threads are then poured out.

The threads do not fill the cell. There is a faintly granular crescentic portion on the side most remote from the duct, which in many cases at least is free. The part of the cell in which the threads lie must be nearly fluid, as it permits oscillations of the threads to take place.

On these points I have satisfied myself by repeated examinations, though the appearances are by no means difficult to make out; and have gone at some length into the question, as so far we have found no satisfactory method of making permanent preparation. All the preservatives at our disposal wrinkle up the delicate cells, with the exception to some extent of weak formation solution; and I have no confidence in that as a means of making permanent specimens.

The whole gland is never involved. In one dissection made by Ross the cells in both middle lobes and in no other part of the gland contained the threads. In several cases where one gland has been exposed entire, the middle lobe alone has been involved; but in the majority all that can be stated with certainty is that the cells in one portion of the gland contain threads, and in other portions they do not.

The following specific observations made by myself on mosquitoes dissected by Major Ross, Dr. Rivenberg of the American Mission, who is working with Dr. Ross, and myself may be of interest.

(*a*) Coccidial cysts full of apparently mature germinal threads, no ruptured cysts, no germinal threads in the body fluids or salivary glands. Two observations.

(*b*) Cysts full of germinal threads, other ruptured empty cysts, germinal threads in body fluids, germinal threads in salivary glands. Over twenty observations.

(*c*) Empty cysts in stomach wall, germinal threads in body fluids of thorax. Germinal threads in salivary glands. No cysts still containing germinal threads. Two observations.

(*d*) Empty cysts only in stomach wall, no germinal threads in body cavity, no germinal threads in well-exposed salivary glands. One observation, the mosquito had been infected four weeks before death.

These observations fully confirm Ross's statements in every point. They indicate that the threads are formed in the coccidia, that they escape on the rupture of these into the body-cavity and

are again collected in the salivary glands. I should have liked to extend the series, but the continued cold weather renders it improbable that I shall be able to do so before I leave.

With your permission I should like to publish an abstract of this, confirming Ross's work; and to this Major Ross consents.

In case you should consider this advisable, I am, to avoid delay, forwarding an abstract to Dr. Manson, with a request to him to forward it to the *British Medical Journal*, if your consent is granted.

The infection of birds free from proteosoma by the bites of mosquitoes.

On December 20, the day before my arrival, twenty-two birds were examined and found free from proteosoma. On that night some of these were used for feeding the mosquitoes which had been infected on November 30 and on the 24th and subsequent days; the remainder of the birds were used for feeding the mosquitoes first infected on November 30 and December 10, 12 and 15. In other mosquitoes of this series germinal threads were found in the salivary glands; and the ones which fed, when examined later, gave the results indicated in paragraph 9.

On December 30 Dr. Rivenberg and myself examined these birds; three of them had proteosoma, two in large numbers.

On January 4 I examined them all except one, which died on January 2; in that the heart's blood contained no proteosoma, and the organs were free from pigment.

Five more of these had now proteosoma, all very numerous. On January 6 and 7 I again examined them; three more had proteosoma, all very numerous.

On January 9 no more cases had developed; but on January 18 one of them had numerous proteosoma, whilst many of the ones which had been infected had recovered, and the others now showed few proteosoma.

Thus twelve out of twenty-two birds became infected, or 54 per cent. This compares unfavourably with Ross's earlier results, as in his published series twenty-two out of twenty-eight were infected, or 79 per cent. But it is to be remembered that at the time he was working the germinal threads were found in a week; whilst in December the development was much slower, and now takes at least twice the time. It is much easier to keep the mosquitoes alive for one week than longer, while in the hot weather mosquitoes bite more readily.

These results are less unfavourable if compared with the normal proportion of birds infected with proteosoma at this season. Thus Ross out of 111 wild birds found proteosoma in 15, or 13·5 per cent.; whilst I find at this season only one with proteosoma out of 30, or 3·3 per cent.

It is possible that in the cold season the birds have a greater power of resistance; and this is rendered more probable by the short duration of the proteosomal attack in my infected birds. Of these twelve, five died within the first week. In three, in which also the proteosoma had been very numerous, none could be found ten days after the invasion; in one, in which they were never numerous, none could be found on the fifth day.

In the other three, very few are now found, though at first they were numerous.

The recovery of these birds and the death of the mosquitoes fed on them diminishes the chances of much future work on this line in the time remaining to me here.

Mention has been made of the differentiation of the contents of the coccidia previous to the formation of the germinal threads into clear and granular; the second of these can be traced day by day into those forming the germinal threads. This differentiation was clearly visible in my series. Instead of germinal threads in a minority of the coccidia, in most mosquitoes, when the germinal threads are mature, black tubular bodies are found in cysts with otherwise clear contents.

These were met with frequently in the series of mosquitoes infected in November and December. Most of these contained some coccidia with black spores; though in few all the cysts contained germinal threads. In some cysts these black spores are numerous and occupy the entire cyst; in other cysts there are only a few. In most cases germinal threads are not found in the same cyst; but there have been a few cysts in which it has been doubtful whether there are germinal threads also in the cyst, or whether there are overlying escaped threads from a neighbouring capsule.

These black spores are very resistent; I have seen some kept in water for months by Ross with no visible change, and they will withstand irrigation with liquor potassæ.

When the cysts are ruptured the spores are found all over the body, but not in cells; nor do they seen to accumulate in any one part of the body.

The most plausible view of the nature of these black spores seems to be that held by Major Ross, viz. that they are "resting spores," and that through them by another cyst the proteosoma can be propagated in conditions unfavourable for direct propagation by injection into a warm-blooded animal.

In that case three courses suggest themselves:

a. From them arise bodies capable of non-parasitic life and possibly of reproduction, but capable at certain stages of their existence of introduction into a warm-blooded host by inhalation through drinking water, or even by injection by a mosquito or other blood-sucker transferring them from the medium in which they live directly.

b. That they may be ingested by mosquito larvæ, and in them undergo such development as will result in the formation of germinal threads in the adult, which in turn might be injected into the bird.

c. That they may, when swallowed or inhaled by a warm-blooded host, so develop as to reach the circulation and pass into the sporulating phase.

Such experiments as have been made are inconclusive; and it is obvious that till the nature of these "black spores" is determined we cannot exclude, even for the proteosoma of sparrows, the possibility of some one of the many alternative possible channels of infection, some of which would only require the occasional intervention of an intermediate host.

Still less are we justified in concluding that malaria in man can only be acquired from the mosquito, or devoting our exclusive attention to that channel.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. E. H. STARLING, F.R.S., has been elected to the Jodrell professorship of physiology in University College, London, in succession to Prof. E. A. Schäfer.

DR. SUTHERLAND, assistant professor of pathology, Glasgow, has been appointed professor of pathology in St. Andrews University, in succession to Prof. Muir, recently appointed to Glasgow.

For some time past the School Management Committee of the London School Board have been considering communications sent to them with reference to the metric system. It has now been resolved to send a memorandum to the Education Department containing proposals for amplifying the teaching of the system by a definite curriculum for each standard.

THE Board of Education Bill was read a third time in the House of Commons on Tuesday. An animated discussion took place upon the various clauses of the Bill, and several amendments were proposed, but no changes of any importance were made. One of the amendments moved had for its object the omission of the words which empower the Board of Education to employ for the purpose of school inspection "other organisations" besides the Universities. These words were struck out in the House of Lords, and re-inserted in Grand Committee in the Commons. The proposal to again delete the "other organisations" was negatived.

AT a meeting of the council of the City and Guilds of London Institute held on Monday it was resolved to confer the Fellowship of the Institute upon Mr. William J. Pope for the valuable and original chemical research work which he has done since he gained his diploma of associate of the institute in 1890; and upon Mr. Arthur E. Childs for the services he has rendered in developing several new branches of engineering industry since he gained his diploma in 1891. The Fellowship is conferred by the council upon those who, having obtained the associateship of the institute and spent at least five years in actual practice, produce evidence of having done some original and valuable research work, or of having otherwise contributed to the advancement of the industry in which they are engaged.

THE Agricultural and Technical Education (Ireland) Bill was read a second time in the House of Lords on Monday. Lord Ashbourne, in moving the second reading of the Bill, said its object is to promote and foster agriculture and all the kindred interests, and also to promote technical education. The Bill in its mechanical part proposes the creation of a department com-

posed of the Chief Secretary, a vice-president, and officials, for whose appointment powers are given. To them will be transferred various powers now scattered over other boards. As to the financial resources to be placed at the disposal of the new department, it is calculated that the total income from all sources will amount to from 160,000*l.* to 170,000*l.* a year; and this money will be applied to aiding and encouraging agriculture and other industries and technical instruction. The board to be formed under the Bill will be aided and advised by three bodies to be called into existence—a council of agriculture, a board of technical instruction, and an agricultural board—which will have very wide and important duties to perform. Speaking broadly and generally, the income of the board is to be devoted as follows: 55,000*l.* to technical instruction; 10,000*l.* to the improvement and development of the sea fisheries; and the remainder to agriculture and rural industries.

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CONTENTS.

THURSDAY, AUGUST 10, 1899.

FLORAS FROM THE ROYAL GARDENS, KEW.

Flora Capensis: being a Systematic Description of the Plants of the Cape Colony, Caffraria, and Port Natal (and Neighbouring Territories), by various Botanists. Edited by W. T. Thiselton-Dyer, C.M.G., C.I.E., LL.D., F.R.S., &c., Director, Royal Gardens, Kew. Published under the authority of the Governments of the Cape of Good Hope and Natal. Vol. VI. Hæmodoraceæ to Liliaceæ. Vol. VII., Parts I. and II. Pontederiaceæ to Gramineæ. (London: Lovell Reeve and Co., 1896–97.)

Flora of Tropical Africa. Edited by W. T. Thiselton-Dyer, C.M.G., C.I.E., LL.D., F.R.S., &c., Director, Royal Gardens, Kew. Vol. VII. Hydrocharideæ to Liliaceæ. Published under the authority of the First Commissioner of Her Majesty's Works and Public Buildings. (London: Lovell Reeve and Co., Ltd., 1898.)

IT should not be necessary at this time of day to emphasise the fact of the imperial character of the Royal Gardens, Kew, still it would appear there are many inhabitants of Great Britain whose notion of the value of this establishment is limited by their desire for a local public park suited to the recreation of dwellers in and about London. Several incidents have of late shown this—witness the recent preposterous proposal brought forward in the House of Commons to throw the gardens open to cyclists! Suggestions of this kind are on the face of them, to those aware of the true character of the gardens, too absurd for discussion, yet there is an element of danger in this appeal to the selfish instincts of that large body of pleasure-seekers who are veritable Gallios in their contempt for science, especially when its just claims place an obstacle to the gratification of their pleasure whims. It is hardly conceivable that any First Commissioner of Works—and he is the Minister responsible for the gardens—would ever assent to such modification of the traditional character of the gardens as concession to the demand above referred to, which may be taken as symptomatic of a craze, would mean; yet in these days of political opportunism, and with a prospect of its even greater development, the preservation of the noble heritage the nation possesses in the Kew of the present becomes a question not altogether free from anxiety in the minds of those who know the services Kew renders and is capable of yet rendering to the Empire. Perhaps the surest way of avoiding disaster in the future is by making known far and wide what are its real functions and how they are discharged, for through the education of public opinion alone can an effective checkmate be given to any movement destined to sacrifice the scientific features of Kew at the altar of popular pleasure.

It is not the intention to discuss here the whole of the functions that belong to and are discharged by Kew—its value as an unrivalled microcosm of the vegetation of the world, its example as a school of horticultural practice, its position as a training ground for young gardeners, its use as an index of the products of the vegetable kingdom and as a nursery and centre of distribution of economic plants for the benefit of our Colonies—but to direct attention to the continued progress, indicated by the titles of the volumes cited above, of the large undertaking to which the energy and foresight of its first Director, Sir William Hooker, committed Kew—namely, the issue of a "Series of Floras" under the authority of the Home or Colonial Governments. Botanists are familiar with what has been already done by Kew towards the carrying out of this programme. The Australian Flora by Bentham and Von Mueller, that of Hong Kong by Bentham, of New Zealand by Dr. Hooker, of Mauritius and the Seychelles by Baker, of the West Indies by Griesbach, and the recently completed British Indian Flora by Sir Joseph Hooker are a tribute alike to the industry and talent of the botanists who have taken part in their production and to the importance of Kew in focussing botanical knowledge, as well as to the labours of our countrymen in the exploration of regions opened up to our occupation. The appearance of the volumes mentioned above has been particularly welcome, inasmuch as they denote a renewal of progress after a pause. The Flora Capensis was arrested after the publication of the third volume in 1865 by the death of Harvey, who, with Dr. Sonder, was its principal author; and of the Flora of Tropical Africa, the last of the three volumes brought out by Prof. Oliver appeared in 1877. The Director of Kew is to be congratulated upon having surmounted the hindrances which have contributed to the delay in continuing these Floras, and he will, it may be hoped, be encouraged to contend with and overcome all obstacles that may as it seems, threaten a steady advance to the conclusion of the works.

The volumes and parts before us are not in sequence with the volumes that have already appeared. As Sir William Thiselton-Dyer points out, once the plan of a work of the kind is settled it is immaterial what part first appears, and he has exercised a wise discretion in giving early attention to those groups of plants which are abundantly represented in our gardens, and which have consequently compelled special attention on the part of members of the Kew staff. The Monocotyledons have been therefore selected for first treatment in the resumed work upon the Floras, and we have the benefit of the ripe experience of Mr. Baker in the elucidation of the Liliaceæ, Irideæ, Amaryllideæ and allied orders, which are so popular in horticulture and form so large an element of the plant-life of South Africa, and to a less extent in the area embraced within the scope of the Tropical African Flora; Mr. Rolfe brings to the enumeration and description of the Tropical African Orchideæ a rare knowledge of the order; and Mr. N. E. Brown describes the Tropical African species of Disa as an expert. Tropical African Hydrocharideæ have fallen to the share of Mr. C. H. Wright, and the Cyperaceæ of South Africa find a sound critical exponent in Mr. C. B. Clarke; the account of the Gramineæ of the same area is in the able hands of Dr. Stapf, and should be completed in the next part of the Flora, for which we trust we shall not have long to wait.

posed of the Chief Secretary, a vice-president, and officials, for whose appointment powers are given. To them will be transferred various powers now scattered over other boards. As to the financial resources to be placed at the disposal of the new department, it is calculated that the total income from all sources will amount to from 160,000*l*. to 170,000*l*. a year; and this money will be applied to aiding and encouraging agriculture and other industries and technical instruction. The board to be formed under the Bill will be aided and advised by three bodies to be called into existence—a council of agriculture, a board of technical instruction, and an agricultural board—which will have very wide and important duties to perform. Speaking broadly and generally, the income of the board is to be devoted as follows: 55,000*l*. to technical instruction; 10,000*l*. to the improvement and development of the sea fisheries; and the remainder to agriculture and rural industries.

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